Orbit

The Journal of the Radio Amateur Space Program

No. 6
March/April 1981
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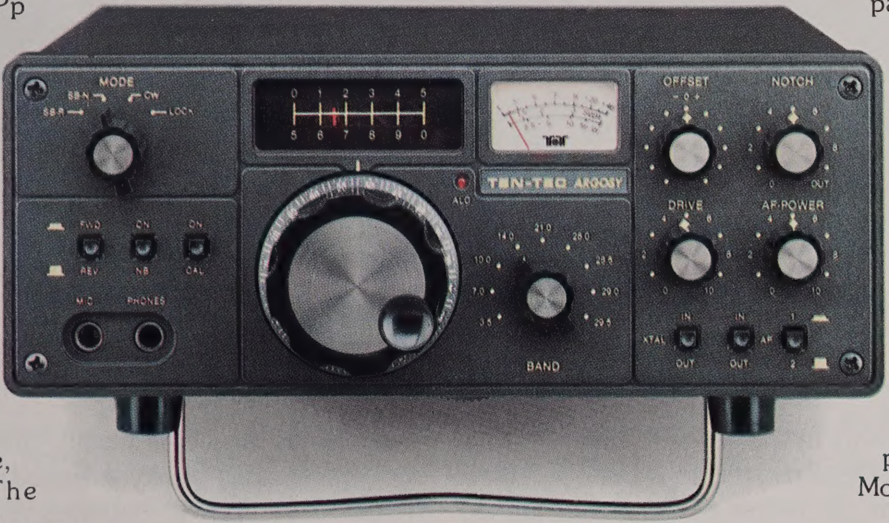

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March/April 1981
Volume 2 Number 2

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Repeater: 146.235/835 MHz

Second Class postage paid at Waterbury, Conn. by *ORBIT*, 221 Long Swamp Road, Wolcott, Connecticut 06716.

ORBIT (USPS 041-850) is published six times per year for $10.(inseparable from membership dues of $16).

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Contents:

Technical Features:

6 **Basic Orbits** By Tom Clark, W3IWI
A description of the basic elements for the Phase IIIB elliptical orbit along with prediction software for personal computers

13 **The AMSAT Amateur Scientific and Educational Spacecraft-UoSAT** By Martin Sweeting, G3YJO
Mission objectives as well as hardware are described in detail

18 **A Calculator For Pre-setting Your Satellite Clock**
By Kaz J. Deskur, K2ZRO *A simple-to-make device that indicates the position of the satellite in terms of minutes after EQX*

21 **AMSAT-OSCAR 7 Between Sunlight and Shadow**
By Juergen Raddatz, DL3ZK *One possibility for variations in satellite temperature*

Informational Topics:

12 **Yuri Gagarin, UA1LO By Joe Kasser, G3ZCZ**
Part 2 of a history of Radio Amateurs in Space

Departments

5 **OFF THE PAD:** *Up, Up and Away* By Joe Kasser, G3ZCZ
31 **Orbital Predictions:** *April through June* By Project OSCAR
31 **Around the World** By Kaz J. Deskur K2ZRO
32 **Letters**
25 **E.M.E. News** By Al Katz, K2UYH
27 **Worldwide Satellite Activity** By Pat Gowen, G3IOR
32 **Satellite Log** By Geoffrey Falworth
33 **AMSAT News**

Our Cover: The cover for this issue was commissioned by the Japanese Amateur Radio League (JARL) for use as a poster to advertise an "Amateur Radio Festival" held in August. Thanks go to Mr. Kaeida (JH1HNH), the JARL, and JR1SWB for arranging permission to use the artwork as our cover.

The festival drew large crowds. JAMSAT set up an OSCAR booth, manned by JA2PKI, JR1FIG and JR1SWB containing an automatic satellite tracking system, consisting of a PC-8001 (a Japanese made microcomputer that looks like a TRS-80 but is more powerful and a lot faster) and an interface unit for azimuth and elevation rotators. The hardware was developed by JA2PKI, the software by JR1FIG and JR1SWB. The system ran all day long. JAMSAT also showed photos of the satellites, had mock-ups of AMSAT-OSCAR 8 and Phase III, sold pre-amp and Mode-J converter kits and distributed a lot of information about satellites in general.

Among the visitors to the stand was a delegation from the People's Republic of China, probably the first official appearance by a group of BY radio amateurs. The delegation consisted of the Secretary General, the Chief Engineer and the official translator for the Chinese Amateur Radio organization.

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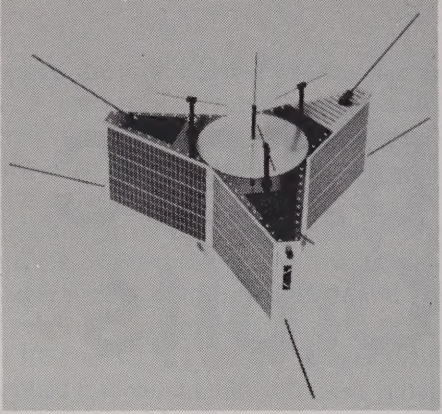
OFF THE PAD

Up, Up and Away!

By Joe Kasser, G3ZCZ

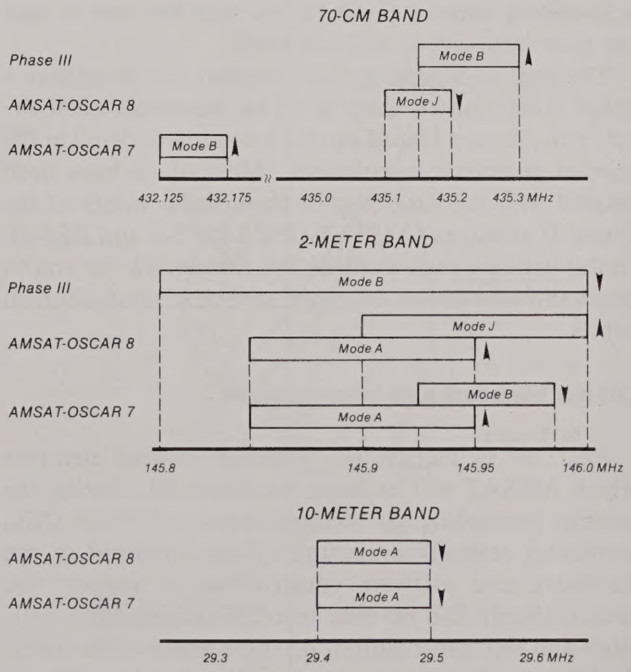


Frequency planning for future amateur communications satellites poses a number of problems. The main one is one that we have in common with the professionals is namely, that there isn't enough spectrum space to go around. Consider the frequencies in use by the Phase II generation and those planned for Phase III as shown in Fig. 1. The first thing that stands out is the overlap.

Shortly after the launch of the AMSAT-OSCAR 7 spacecraft, it was found that every few months, as AMSAT-OSCAR 7 overtook its older brother AMSAT-OSCAR 6, the Mode B downlink on AMSAT-OSCAR 7 could access the Mode A uplink in AMSAT-OSCAR 6, and a number of inter-satellite QSO's were made. In those days, the number of users was relatively small and the interlinking was exciting, posed a challenge and was fun. During the time periods when the spacecraft were in close proximity, instances of Mode A uplinks aimed at AMSAT-OSCAR 6 causing QRM to the AMSAT-OSCAR 7 Mode B downlink occurred. Again at that time the number of users was small, so the situation did not occur too often. With the demise of the AMSAT-OSCAR 6 spacecraft and the subsequent launching of AMSAT-OSCAR 8, a new situation was created. The only inter-satellite QRM that occurs now, is if stations aiming at one spacecraft in Mode A also access the other, but since the passbands are almost identical, the situation tends to pass by unnoticed. At weekends when AMSAT-OSCAR 8 is operating in both Modes A and J, stations working one mode can unintentionally QRM stations working the other mode. Since for some reason Mode J is not very active, the potential for QRM remains just that.

The Phase II satellites provide relatively "local" coverage. Phases III and IV will provide worldwide coverage. It is well known that Mode A provides an ideal introduction to satellite communications, since the vast majority of hf operators have receivers that cover 29 MHz. In 1972 when AMSAT-OSCAR 6 was launched, operation on two meters was relatively rare. Many stations who purchased two meter transverters for use with AMSAT-OSCAR 6, especially in remote locations, had no way of finding out if the receive converter was working—their being no one else to work locally on the band. Since then, the number of vhf/uhf only operators has grown fantastically and, with the ubiquitousness of two-meter fm, the 144-146 MHz band has filled up. In nearly every major city in a country in which amateur radio is legal, the two-meter fm channels are occupied! An outline of the band occupancy for the two-meter band in IARU Region 1 is shown in Fig. 2. There are 10 fm repeater channels at 25 kHz spacing starting at 145.00 MHz (input). Note that the R8 (145.8 MHz) and R9 (145.85 MHz) repeater channel output frequencies which fall in the segment of the band allocated to spacecraft communications are being phased out. In Europe in particular, the cw/ssb segments are very active, in other parts of the world fm spreads beyond the allocated channels. I listened in on fm conversations on 145.95 MHz while in Tokyo last year. There is thus no place to put a second satellite communications segment in the two-meter band. The use of the 10-meter band for Phase III type transponders is difficult technically due to the state of the art in amateur spacecraft hardware technology at this time. Thus, Mode B was chosen for Phase IIIA in spite of the potential for QRM with Phase II communications, because AMSAT has a policy of not obsoleting user equipment.

Fig. 1 — Satellite spectrum usage.



(Continued on page 11)

BASIC Orbits

By Tom Clark, W3IWI*

In AMSAT's plans for support of the Phase IIIA launch, I had the responsibility for producing the necessary software for ground support of spacecraft navigation activities. One of the software modules which I developed allowed each of the Phase III telecommand stations to produce azimuth, elevation, range and doppler predictions for a given set of orbital elements.

The international AMSAT team is again hard at work preparing the Phase IIIB/C spacecraft, and many of you, the users, have asked for elliptical orbit prediction software that you can use on your personal computers. The program presented in this article was written in North Star BASIC, a common dialect of BASIC, but the concepts are generally applicable to any of the other common dialects. AMSAT-HQ has received a number of contributed programs from around the world (see acknowledgements). Some of you who sent one in may see your influence in this software.

The goal in producing this program was to achieve a range prediction accuracy of 10 km anywhere in the orbit. This, in turn forced careful attention to detail in the myriad geometric calculations. Most of us have been spoiled with the simplicity of the circular orbits of the Phase II satellites (AMSAT-OSCAR's 5-8 and RS1-2). In this article I shall establish the framework for you to begin thinking about the more general case of elliptical orbits.

Orbital Elements and Nomenclature

First, let us clarify the "official" orbital elements which AMSAT will be using for Phase III. During the months preceeding the ill-fated launch of Phase IIIA, confusion seemed to abound. Those involved in the hardware and software construction to support the launch simply had no time to communicate their decisions and recommendations on these topics to the users. A lot of rhetoric concerning "apogee-based" vs. "perigee-based" solutions to the orbit prediction problems appeared in correspondence and Amateur Radio journals. It is hoped that this article will establish a set of standards on which we can all agree, and I hope that this information will reach all the users in time for them to be ready for the Phase IIIB launch next year.

On the question of orbital elements, Dr. Karl Meinzer, DJ4ZC, (for the IHU—the on-board spacecraft computer) and I reached the same basic decision: The PRIMARY elements should be the classical Keplerian set of six numbers:

[I0] = Inclination (Degrees)
[E0] = Eccentricty (Dimensionless)
[W0] = Argument of Perigee (Degrees)
[O0] = Right Ascension of Ascending Node (Degrees)
[M0] = Mean anomaly (or orbit "phase") at reference epoch [T0] (Degrees)
and either
[A0] = semi-major axis of ellipse (Kilometers) or
[N0] = mean motion (orbits per day)

Let me now introduce the notation I will follow in this article. When describing a variable or function, the name (as it appears in the program) will be enclosed in [. . .] square brackets. When a line number is referenced, it will appear in {. . .} braces.

The latter two parameters, [A0] and [N0], are closely related and only one needs be specified. This is because one can be derived from the other, given knowledge of the mass of the earth, as shown in the equations of lines { 10140-10150 }.

A seventh number also must be specified, the epoch date and time [T0] for which the elements are given. In picking names for the variables, I have attempted to follow conventional professional nomenclature where possible; however in most texts you will find the Argument of Perigee written as ω (lower-case Greek Omega) instead of [W0], and the Right Ascension of Ascending Node (which I will subsequently abbreviate R.A.A.N.) written as Ω (upper-case Greek Omega) instead of [O0]. I also, have adopted the convention that reference orbital elements have the postscript 0 (e.g. [T0], [W0], etc.). When the parameters are evaluated or updated at a later epoch (typically [T], then the postscript 0 is dropped (e.g. [M] is the value of the mean motion at the epoch [T]). The initial angular units are in degrees, but within the computational loop, angles are in radians. The conversion between degree and radian measure uses the constants [P1] = π, [P2] = 2π and [P0] = π/180. Internally, times (e.g. [T]) are measured in units of days and fractions of a day, and distances are in kilometers.

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*President, AMSAT

I referred to the above set of elements as PRIMARY. For those users who want other numbers (like a table of apogee or perigee times, times and longitudes of equator crossings, etc.), I would note that *your needs can be DERIVED* from this set. If the users indicate a strong desire for a particular type of DERIVED elements, they could be made available for publication in *ORBIT* just like the equator crossing times and longitudes are given for AMSAT-OSCAR's 7 and 8. We want to hear of your requirements!

Another point of departure from our circular orbit experience is in my recommendation for the numbering of orbits. For the low-altitude circular orbits (where the concepts of apogee and perigee break down), historically we have used the north-bound equator crossing as the start of a given numbered orbit. But for the high-altitude elliptical orbits, I suggest (and this program uses) the convention that orbits are numbered in terms of perigee passages. For the user who operates when the satellite is near apogee, the orbit number will not change during a given 6-10 hour pass. I note philosophically that this convention is similar to that employed in ordinary time-keeping—the date increments at midnight, but our human life-styles center on noon. The use of this convention also simplifies the computational software—if we keep track of the mean anomaly in revolutions, then the integer part is the orbit number, and the fractional part is related to the phase within the orbit. The parameters [K0] and [K] are the integer orbit numbers just described evaluated at the reference epoch [T0] and the calculation epoch [T], while [Q0] and [Q] are the integer plus fractional orbital phase at the two epochs. In DJ4ZC's software resident in the spacecraft's Integrated Housekeeping Unit (IHU) there is a clock representing the phase (or mean anomaly) that has a value of zero at perigee and increments up to a count of 255 (each step is approximately 2.6 minutes) through the orbit. This clock will be made available to the users via the beacon. The software presented here calculates the modulo-256 phase as [M9].

The Satellite's Position in its Orbit

A satellite in orbit about a parent body which can be represented as a point-mass (like a black-hole?) would trace out the path of a perfect ellipse (see Fig. 1), and its motion will be confined forever to lie in a single plane.

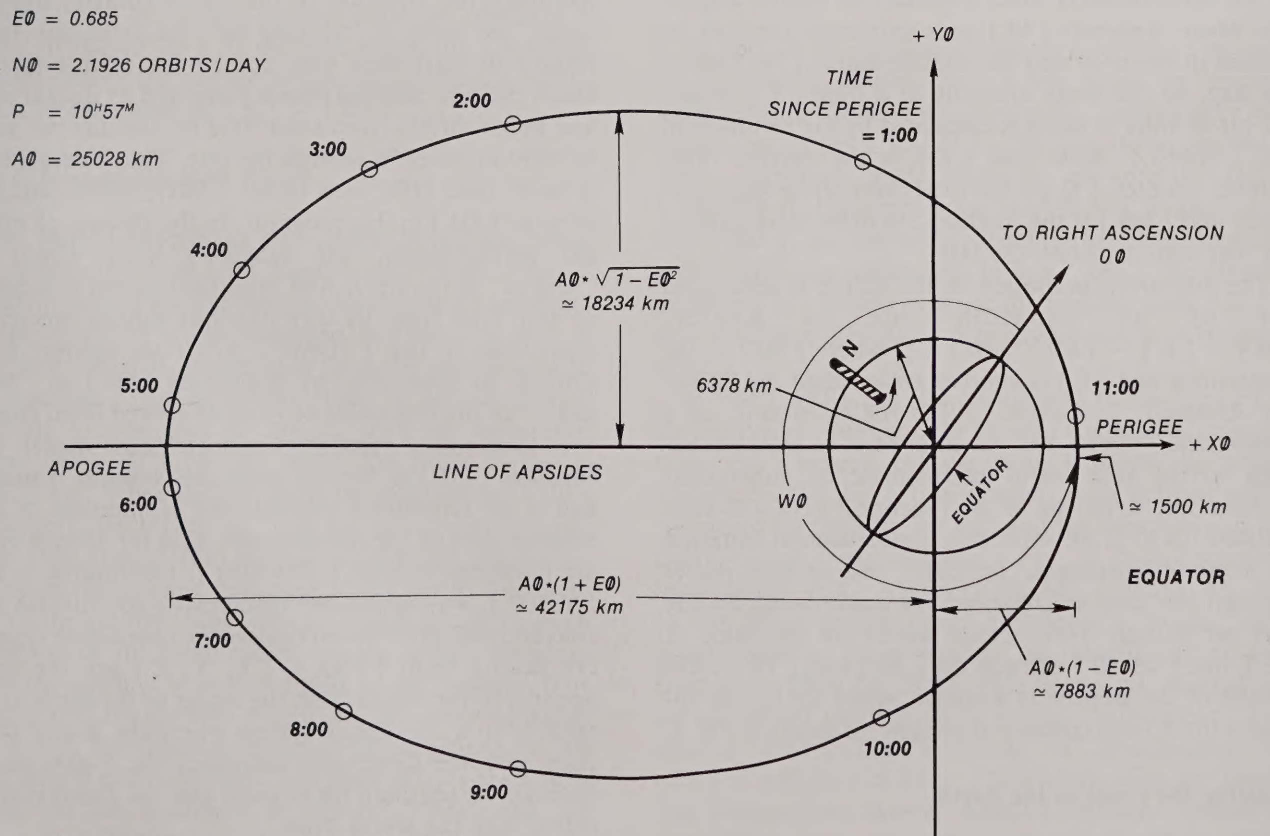


Fig. 1 — The planned elliptical orbit for Phase IIIA.

The point-mass will be one of the foci of the ellipse. The major axis of the ellipse passes (by definition) through the point-mass, and defines a line known as the *Line of Apsides.* When the satellite is on this line and closest to the point-mass, it is said to be at *Periapsis* (or *Perigee* if orbiting the earth, *Perihelion* if orbiting the sun). When at its maximum distance, it is said to be at *Apoapsis* (or *Apogee* or *Aphelion*).

The flatness of the ellipse is specified by the dimensionless number, the *Eccentricity* [E0], which approaches zero for a nearly-circular orbit (like that of AMSAT-OSCAR's 6, 7 and 8), and tends toward 1.0 for a very flat ellipse. Fig. 1 shows an ellipse with [E0] = 0.685 typical of the desired final orbit for AMSAT's Phase III satellites. At apoapsis (or apogee), the satellite is at a distance of [A0] * [1 + E0] from the point-mass, while at periapsis (or perigee), the distance is [A0] * [1 – E0], where [A0] is the *Semi-Major Axis* of the ellipse. For the case of a perfect circular orbit with [E0] = 0, the distances are the same, the distinction between apoapsis and periapsis is lost, and the line of apsides is undefined. For the rest of this discussion, we will consider a satellite in orbit about the earth and use only the names apogee and perigee.

As the satellite moves in its orbit, its velocity is not uniform. One of Kepler's laws states that in equal intervals of time, equal *Areas* will be swept out. Fig 1 illustrates this with tick-marks at uniform 60-minute intervals around the orbit. For any given orbit, let us begin measuring time (or orbit phase) as the satellite goes through perigee. Astronomers historically have used the (anomalous?) word *Anomaly* to denote angles. The *Mean Anomaly* [M] goes uniformly through 2π radians in one orbit and the satellite makes [N0] orbits per day, so the mean anomaly at a time [T] (where [T] is in units of days) is calculated by the formulae in line { 10350 }. Note that [K] is the current orbit number counter, [Q] is the total orbit phase in revolutions, and [M9] is the modulo-256 orbit clock mimicing that maintained by the IHU.

The non-uniform motion in the ellipse is accounted for by an equation due to Kepler, [M] = [E] – [E0] * sin [E], where [E0] is the eccentricity and [E] is another angle called the *Eccentric Anomaly.* The angle [E] is the by-product of a geometrical "trick" and has little basis in reality other than serving as a useful intermediate for subsequent calculations. Referring to the function [FNK] in lines { 10420-10430 }, we solve this transcendental equation by iterative techniques. Typically, one to four passes through the loop are required for convergence to one part per million. Having thus solved for the value of [E], line { 10450 } extracts the [X0] and [Y0] coordinates of the satellite in a system where the line of apsides is the X0-axis (positive at perigee), as shown in Fig. 1.

Relating the Orbit to the Earth

So far, we have only specified positions in the plane of the orbit. Three more orbital elements—all angles—allow us to transfer these positions to the earth. The *Inclination* [I0] is the tilt angle between the orbit plane and the plane of the earth's equator. The *Argument of Perigee* [W0] is the angle in the plane of the orbit between a north-bound equator crossing and perigee. In the example shown in Fig. 1, [W0] is about 300 degrees, while the inclination [I0] is about 60 degrees.

The third angle [O0] is called the *Right Ascension* of the *Ascending Node* (R.A.A.N.). If we take the line defined by the intersection of the orbit plane and the equator, and project it onto the sky until it intersects a star, then [O0] is the longitude-like celestial coordinate which astronomers call the Right Ascension of that target star. If the satellite were in orbit about the hypothetical point-mass we postulated earlier, and if the gravitational fields of the sun and moon were to be switched off, then the orbit plane would maintian its orientation with respect to the target star forever. The coordinate rotation necessary to transform from the orbit plane into star-based inertial celestial coordinates uses the equations in line { 10470 }, where the rotation matrix [C] (dimensioned 3 x 2) was previously constructed in lines { 10270-10290 }.

Since our clocks on earth are referenced to the sun, we must now convert from star-based *Sidereal Time* into solar-based *Coordinated Universal Time* (UTC). For those not familiar with sidereal time, let me digress briefly. Let us consider the time that a star transits (or rises, or sets), as measured by our normal clocks. Each day the star will appear about four minutes earlier. Although the direction to the star is (nearly) fixed in space, the earth is "picking up" an extra day (with respect to star) each year due to the earth's motion about the sun. Sidereal time is measured by distant stars and hence differs from solar time by one day per year, or three minutes 56 seconds per day. Thus sidereal time is faster than UTC by a factor 1.0027379093, which is denoted [G1] in this program. In the absence of external perturbations, the satellite's orbit would be "locked" to the stars. And thus, the concept of sidereal or star time finds its way into our orbital prediction algorithms in line { 10490 }, where we convert from sidereal to solar time by evaluating [G7] as "hour angle" of the first point of Aries as viewed from Greenwich (commonly called the Greenwich hour angle). The constant [G2] is derived from the Nautical Almanac and is the Greenwich sidereal time at midnight of day number zero of the current year; data for several years are tabulated in lines { 990-1050 }. Continuing in line { 10500 }, we express our spacecraft's coordinates in a conventional earth-based *Geocentric* coordinate system. On exiting from [FNK], [X, Y, Z] are the components of the vector from the center of the earth to the satellite in a coordinate system where the X-axis coincides with the Greenwich meridian, the Y-axis passes through the southern tip of India and the Z-axis is coincident with the North Pole.

For those of you who have grown up with the luxury of sun-synchronous satellites in (nearly) circular orbits (like AMSAT-OSCAR's 5-8), the concepts of sidereal time and celestial coordinates may seem strange and counter to your experience. We shall resolve your enigma shortly! To help ease the transition from equator crossing longitudes to R.A.A.N., I've included a short utility program to do all the hard work. It even includes an example for calculating R.A.A.N., given launch date and time, for a typical Ariane launch from Kourou. (See page 29.)

From the Observer to the Satellite

Most of the hard work is done now. In the function [FNX], beginning in line { 10630 }, we now placate the observer by figuring all the parameters of interest. Previously in [FNO] we had calculated the vector from the center of the earth to the observer and deposited it in [X9, Y9, Z9]. This vector is subtracted from the geocentric spacecraft vector [X, Y, Z] in line { 10660 } and the resultant is the observer-to-satellite vector [X5, Y5, Z5] and range [R5]. For later calculation of doppler shifts, the change in range since the last calculation is extracted and converted into a velocity [R8] in lines { 10680-10690 } by finite differencing. Note that the velocity thus determined is the average since the previous step through the loop, and therefore it best represents the velocity one-half a step time earlier. The [X5, Y5, Z5] vector is rotated into a coordinate system centered on the observer (e.g. up, north and east), and the azimuth [E9] and elevation [A9] are computed in lines { 10720-10750 }. Finally, the longitude [W5] and latitude [L5] of the sub-satellite point are obtained in lines { 10760-10770 }. If the user wants the spacecraft altitude (above the surface of the mean spherical earth), it can be calculated as [R] − [R0].

The Effects of the Real World

The earth is not a black hole (fortunately!) and hence the satellite is not in orbit about a point-mass. Even if the earth were a perfect sphere, the model we have just developed would still be adequate. But alas, the earth is an oblate spheroid, flattened at the poles and bulging at the equator. The deviation from a perfect sphere amounts to one part in 298.25, with the equatorial radius being 6378.16 km, while the polar radius is 6356.77 km. When the satellite is far from the earth (like at apogee), the effects of "real world" lumpy gravitational field arising from the equatorial bulge is minimal. But when the satellite gets close to the earth, the direction of the gravitational force no longer passes through the center of the earth except for the special instances when the satellite is over the pole or the equator. The result is that the satellite essentially loses track of which way is up! This in turn results in perturbations on the nice, simple elliptical orbit. The main effects are a slow change in the argument of perigee [W0] and the R.A.A.N. [O0] by the amounts given in the equations in lines { 10190, 10220 and 10240 }. [W] and [O] are the updated values of these parameters recomputed each orbit as the satellite passes through perigee. The updated values are then used to re-initialize the coordiate rotation matrix array [C] in lines { 10270-10290 }.

Our old friends, the sun-synchronous satellites, make use of this "dragging" of the orbit by the earth's non-uniform "lumpy" gravitational field to keep their orbit plane locked to the sun. This is accomplished by very careful navigation and guidance throughout the entire "burn" of the launch vehicle. These satellites were intentionally put into an orbit where the changes in the R.A.A.N. [O] would just compensate for the difference between sidereal and solar time. An exercise left to the reader is to plug in the parameters for one of these sun-synchronous satellites and see if you can account for a change in [O] of three minutes, 56 seconds per day.

Not included in the software presented here are higher order gravitational perturbations, atmospheric drag, effects of the solar and lunar gravitational fields, relativistic effects, precession and nutation of the earth's spin axis, polar motion, variations in the rotation rate of the earth, etc. These would all be required if our desired accuracy were at the 1 km (or less) level but can be ignored at the 10 km accuracy level.

The oblateness of the earth also enters into the determination of the observer's coordinates. The function [FNO], beginning in line { 10520 }, takes account of the geometrical flattening, as well as correcting for the given units of meters.

The Control Program

So far, all of our discussions have revolved around the supporting utilities. Now a few words on the program itself. Following a commercial, clearing the CRT screen, etc. (lines { 10-120 }), the user inputs the date, time, duration and step-size parameters (lines { 130-270 }). Data tables are read in and, beginning in line { 360 }, the user selects from the satellites currently coded into data statements. In line { 390 }, the dummy variable [D] is used to space through the data. [D] is also used as a dummy in many other places in the program.

In line { 440 }, the user is allowed to specify [F1], the equivalent frequency to be used for doppler calculations. For a beacon, this parameter is simply the carrier frequency. But for a transponder, with doppler shifts occurring on both the up-link and the down-link, it requires some explanation. For a non-inverting transponder (e.g. AMSAT-OSCAR 7 Mode A), the 145.95 MHz up-link signal undergoes a doppler shift proportional to the product of the velocity and up-link frequency. Then the 29.45 MHz down-link experiences an additional doppler shift, so the "equivalent" frequency [F1] for a Mode A transponder is [F1] = 145.95 + 29.45 = 175.4 MHz. For an inverting transponder like on AMSAT-OSCAR 7 Mode B (and Phase III), the uplink signal at 432.15 MHz undergoes a doppler shift proportional to the up-link frequency. Then in the spacecraft's transponder, the passband is inverted—an upwards drifting signal is converted to one which drifts downwards. On the spacecraft down-link at 145.95 MHz, the signal once again is subjected to an additional doppler shift, yielding an equivalent frequency [F1] = −432.15 + 145.95 = −286.20 MHz. The use of a negative sign on the uplink frequency is necessary to account for the inverting transponder and resulting "start low-end high" doppler which occurs during a pass in this mode.

After initialization of the [FNC] and [FNM] routines in line { 570 } and printing out a summary of the parameters in lines { 510-660 }, the actual computational loop follows in lines { 680-830 }. Most of the code is concerned with calls to the functions described earlier, and book-keeping for above/below horizon, new orbit and new day cases, and finally printing the results. You may very well want to customize several of these sections to meet your own specific requirements.

Some Comments on Style, Tricks and Dialects

I attempted, within the limits of BASIC to employ certain precepts of structured programming in this code, but in doing so, I may have hampered transportability. The entire set of utilities in lines { 10000 } onwards were developed and tested as modules before final program integration. I found it very convenient to use a "trick" available in North-Star's ("N*") BASIC utilizing multiple line functions as "GOSUB by name". For example, consider the function [FNO] in lines { 10520-10620 }, which is included within a " DEF FN......FNEND " structure. Line { 10610 } ends with " RETURN 0 " and the [D] of " DEF FNO(D) " was never used. All the variables referenced within [FNO] are "global" and available to all other routines. Thus in line { 340 }, when I envoke " D=FNO(D) ", I could have just as well written " GOSUB 10530 ". [D] is just a dummy variable and conveys no information. Why not use a more conventional approach? First, I chose to write all routines as modules. I did not want to be bothered with insuring that all references to line numbers were updated when I worked on a module. Second, I regard a name like " FNO " (where to me O means observer) as slightly more information than a criptic " 10530 ". It's all a matter of taste.

The program was written using North-Star's (N*) Disc BASIC, which most of the Phase III telecommand stations have adopted (along with AMS80 and IPS) as a standard. Not surprisingly, this is probably not the same dialect of BASIC that you use, and it will be your burden to handle the translation. To assist you in this honorous task, let me point out some of the known dialectic quirks. N* uses the "backslash" ("\") for a multiple statement per line delimeter, while other BASIC's often use ":". N* uses the FORTRAN-like spelling "SQRT" instead of the more conventional "SQR" for square-root. N* lacks a "PRINT USING" feature, but makes up for the lack by allowing FORTRAN-like formatting practices. In { line 270 }, "%10F4" is just like FORTRAN's "F10.4", meaning a 10 character wide field with four digits to the right of the decimal point. Similarly, in line { 810 }, "%6I" means a six character wide integer format. N* permits "RESTORE 1120" in line { 400 }, while some dialects do not support "RESTORE" to a line number. N* allows only one character (e.g. [A] through [Z]) or one character plus digit (e.g. [A0] through [Z9]) variable names, while many other BASIC's permit longer and more descriptive names. The multi-line, multi-variable functions like [FNA] in line { 10010 } treat both [X] and [Y] as dummy variables. All variables in such a "call" to a function are local, while variables not appearing in the "call" are global. You may have trouble in other dialects. "FNEND" can be followed by any text (e.g. the "----" in line { 10100 }) and I use this "quirk" to help separate modules.

N* allows the use of assignable I/O devices in PRINT and INPUT statements. This is seen in lines { 510-660 } and elsewhere, wherein "PRINT#P9,...." sends the output to the logical device [P9], where [P9] is a number between 0 and 7 which the user has assigned to a physical output device. In the absence of a specification, logical device #0 is assumed, and all the N* users have device #0 assigned as the console. In line { 140 } you will find " INPUT1... ". " INPUT1 " is just like " INPUT " except that it supresses the carriage return/line feed in the echoed response. N* permits concatination of strings with the "+" operator. In line { 790 }, we assemble a string consisting of two characters for the hour, two for the minute, a ":" and two characters of seconds, all of which represent the epoch time with no zeroes supressed.

This program has been run under both Single- and Double-density N* BASIC and requires about 10-11 kBytes of user RAM space with all the REM's and data statements included. It would be shortened considerably by stripping REM's and reducing the number of data statements. Typical program execution speed (with an 8080 running at 2 MHz clock rate) is a few seconds per loop through lines { 680-830 }. We have used both the (normal) N* 8-digit BASIC and N*'s special 14-digit BASIC and find that the higher precision slows execution about 30 percent with some improvement in accuracy. The major accuracy improvement comes from the elimination of round-off errors on the variable [T].

The author will make machine-readible copies of this program available on Single-density North-Star diskettes for a $15 contribution to the Phase III hardware development fund.

Acknowledgements

Translations of this program to other dialects has already begun thanks to the efforts of the following:
CP/M, C-BASIC and M-BASIC, D. Biggar (ZL1WN's son); TRS-80 Level 2, G. Roberts (ZS1BI); Apple-2, W. McCaa (K0RZ); Alpha Micro BASIC, J. DuBois (W1HDX).

If you express enough interest, perhaps this and other AMSAT software will be made available through the AMSAT Computer User's Group being established by WD9ICG and N5AHD. We would like to hear of other translations too.

I would like to offer my thanks to all of you who worked on your own software for the elliptical orbits of Phase III. The contributions of programs in BASIC came from C. McCluer (W8MQW), J. Fleagle (W0FY), W. McCaa (K0RZ), R. Imaizumi (JR2BQN), M. Nakayama (JR1SWB), R. Zwirko (K1HTV), J. McKim (W0CY), G. Roberts (ZS1BI), and the extensive commercial SatTrack package (reviewed by KA9Q in *ORBIT*, Nov./Dec. 1980, pg. 31.) FORTRAN software was contributed by M. Davidoff (K2UBC), N. Janssen (PA0DLO) and P. Bell (VK3ZZF). An HP-67/97 program was contributed by R. Welsh (W0SL) and is available from the HP Users Group. The W0SL program was modified for the HP-41C by R. Jansson (WD4FAB). Another HP-41C program by P. Bunnell (WA6VJR) appears in *Ham Radio*, March 1981, pg. 46.

(Continued on page 19)

Up, Up and Away *(Editorial continued from page 5)*

The potential here is for uplinks aimed at Phase II satellites to cause QRM to the Phase III downlink, but AMSAT expects that once users find out how easy, and how much better Phase III communications are, very few people will try working a Phase II bird if a Phase III is in range. The QRM problem will thus cease to exist.

With Phase IV following closely behind Phase III, there is no way that Mode B can be used without a tremendous QRM problem and so Mode M has to be the way. The state of the art with Mode M at this time is analagous to that of Mode A in the days before the launch of AMSAT-OSCAR 6. The 70-cm band space segment (435-438 MHz) is relatively empty (just like 29 MHz was then). The 23-cm band is even emptier, just like two meters was then.

The choice of uplink and downlink Mode-M frequencies is also not so easy. The 435-438 MHz allocated to the Amateur Satellite Service is used by Amateur fast-scan television. At 1260 MHz, we find that 1260.15-1261.35 MHz has already been allocated as fm repeater output channels (150-kHz spacing) in Region 1. We thus can't pick 1260 MHz as a Mode-M uplink, but will have to use something in the 1269/1270 MHz range.

Mode A has been flown on all Phase II satellites to date. The transceiver or transverter used to generate the Mode-A uplink can be used to copy the Mode-B downlink. Mode J allowed the Mode-B equipment to be used in reverse. (The change from 432 MHz to 435 MHz between AMSAT-OSCAR's 7 and 8 was due to a change of frequencies allocated to the Amateur Satellite Service).

The equipment thus used to copy Mode J can be used to copy Mode M. The state of the art of transmitting equipment for Mode M is not that different than the state of the art in two-meters and 70-cm transmitting equipment only 10 years ago, which just goes to point out the advances in the state of the art in two-meter equipment, mainly brought about by OSCAR and two-meter fm.

With operational Phase III and Phase IV Mode-M transponders, 1270 MHz equipment will become commonplace. Advertisements for 23-cm equipment are already appearing in Japan's outstanding amateur radio magazine *CQ Ham Radio*. Mode M is the only way to go.

CW	144,000 144,150	144,000-144,010 Moon bounce 144,050 CW Calling
CW SSB SSTV	144,150 144,200 144,300 144,500	144,300 SSB Calling 144,500 SSTV
All modes	144,500 144,700	144,600 RTTY Calling 144,700 FAX
FM Repeater Input	144,725 144,800	
All modes	144,800 144,900	
Beacons	144,900 145,000	Regional beacons
FM Repeater Input	145,000 145,175	
FM Simplex	145,200 145,300	RTTY
FM Repeater Output	145,325 145,400	Output
FM Simplex	145,425 145,500 145,575	Mobile calling
FM Repeater Output	145,600 145,775	
Satellite Service	145,800 146,000	

Fig. 2 — Outline of the Region 1 two-meter band plan.

A HISTORY OF RADIO AMATEURS IN SPACE — PART 2

Yuri Gagarin, UA1LO

(1934 - 1968)

*By Joe Kasser, G3ZCZ**

While radio amateurs in the U.S.A., inspired by Sputnik 1, were dreaming of building and flying their own spacecraft, at least one radio amateur had made up his mind to go into orbit in person. Yuri Alexeivich Gagarin, UA1LO, became the first known man in space on April 12, 1961 when his Vostok capsule made one orbit of the earth in 98 minutes at a maximum altitude of 188 miles.

Twenty years ago, in 1961, the space race was nearing its climax. On February 21st the American Mercury capsule underwent re-entry trials, on March 18th the emergency separation procedure was tested, but was not fully successful. As a result, instead of the first suborbital trajectory manned flight taking place as scheduled on March 24th, another trial took place. The next day Russia launched and recovered its fifth orbiting cabin, a cabin that could have contained a man, but carried a dog, mice, guinea pigs, frogs, bacteria, viruses, fungi and plant seeds instead.

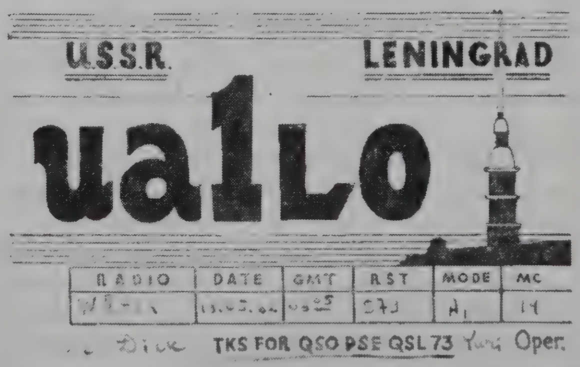
On April 12, 1961, while the International Space Research Organization (COSPAR) was holding its second annual symposium in Florence, the Soviet Union announced that Major Yuri Gagarin had made his single orbit and had returned to earth.

Yuri was born on March 9, 1934 in Gzhatsk, near Moscow. He graduated from the Soviet Union's Air Force Academy Cadet Training Center. Although he only made one space flight, he was active in the space program as a Commander of Cosmonauts and was chief of training experiments. His honors included the Order of Lennin and he was also a hero of the Soviet Union. Yuri was killed on March 27, 1968 near Kirzhach, when an experimental plane that he was test flying crashed.

Yuri had traveled in the West as an ambassador of goodwill, following his space flight, and his cheerful personality and friendliness had won him many friends who keep his memory alive in their hearts.

Editor's Note: March/April 1981 is the 47th anniversary of his birth, the 13th anniversary of his death and the 20th anniversary of his space flight.

PRIMUL OM IN COSMOS
I.A.GAGARIN
1961
1.35 LEI
R.P.ROMINA POSTA AERIANA
СССР
СЛАВА СОВЕТСКОЙ НАУКЕ И ТЕХНИКЕ!
12-IV-1961
6
«Наш народ первым проложил путь к социализму. Он первым проник в космос, открыл новую эру в развитии науки...»
Н. С. Хрущев.
20 BANI
POSTA ROMANA
ЧЕЛОВЕК СТРАНЫ СОВЕТОВ В КОСМОСЕ
КОСМОНАВТ
3



U.S.S.R. LENINGRAD

ua1LO

RADIO	DATE	GMT	RST	MODE	MC
[illegible]	[illegible]	[illegible]	[illegible]	A1	14

Dick TKS FOR QSO PSE QSL 73 Yuri Oper.

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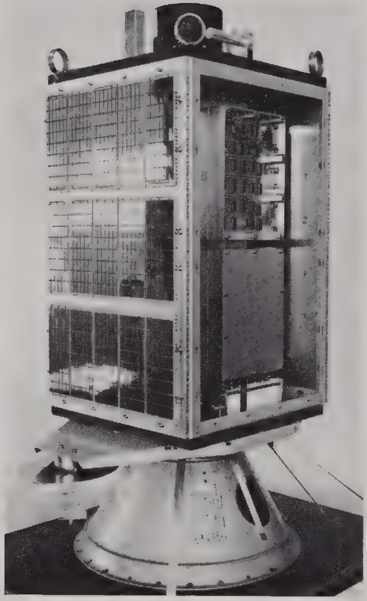
*Editor, Orbit Magazine

The AMSAT Amateur Scientific and Educational Spacecraft — UoSAT



Here are the preliminary details

*By Martin Sweeting, G3YJO**

The Radio Amateur Satellite Program, born in 1961, has witnessed a total of ten amateur spacecraft launched successfully into earth orbit - of which five may be considered experimental (Phase I) and five developmental (Phase II).

The early experimental satellites (OSCAR's 1 to 4) were managed by Project OSCAR, Inc. (USA) while the development satellites AUSTRALIS-OSCAR 5 and AMSAT-OSCAR's 6, 7 and 8 were launched under the auspices of the Radio Amateur Satellite Corporation (AMSAT) based around Washington, D.C. Two further development spacecraft (RS 1 and 2) have also been launched successfully by the USSR.

The first amateur spacecraft to be considered fully operational emerged from the AMSAT Phase III program earlier this year, however a failure of the Ariane launch vehicle has delayed the realization of this operational stage until mid-1982.

Although the Radio Amateur Satellite Program has reflected a substantial educational flavor, the emphasis during Phase II and Phase III has been on producing Communications Satellites primarily intended for increasing vhf/uhf communication range between Amateur Radio operators. Amateur Radio is very much a self-learning and training activity even in its simplest manifestation and, as with other amateur off-shoots of professional activities (such as amateur astronomy) has by its peculiar resources contributed much to the overall understanding of its field. In recent years Amateur Radio has perhaps developed stronger communication skills at the expense of experimental skills largely due to the impact of relatively cheap, mass-produced, high-technology equipment and has in turn tended to discourage the broader audience of amateur scientists, technicians and dabblers who could so enrich the fraternity.

In an attempt to redress this imbalance, the AMSAT group in the United Kingdom (AMSAT-UK) is constructing an Amateur Scientific and Educational Spacecraft (UoSAT) specifically aimed at generating interest among a wide range of imaginative individuals in an important but now largely neglected aspect of Amateur Radio. UoSAT is being constructed at the University of Surrey (UK) and is supported by AMSAT, the Radio Society of Great Britain (RSGB), British Industry and Research Organizations.

Mission Objectives

The mission objectives may be summarized as follows:

- To provide Radio Amateurs with a readily available tool for the study of the propagating medium through which they communicate from hf to microwave frequencies.

- To stimulate a greater degree of interest in space sciences among schools, colleges and universities by enabling active participation.

- To broaden the scope of the Radio Amateur Satellite program and to encourage the interests of Amateur Scientists.

- To establish an active body in the UK with the necessary resources to contribute flight hardware to the Radio Amateur Satellite Program.

- To study and evaluate the suitability of novel methods and new frequencies for use in subsequent amateur spacecraft.

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Spacecraft Systems

The spacecraft systems may be considered in three components - service modules, experiment modules and the mechanical structure.

The service modules comprise all the functions fundamental to the basic operation of the spacecraft, such as the power sources, power conditioning, telemetry system, telecommand system, the General Data Beacon and the Engineering Data Beacon.

Power Source

Four body-mounted solar array panels each provide 17 Wdc when fully illuminated. The average power available from the arrays will be approximately 25 Wdc.

Battery Charge Regulator (BCR) and Power Conditioning Module (PCM)

The BCR regulates the solar array power supplied to the 6 AH 14 Vdc NiCd battery pack with an efficiency around 90 percent. The PCM delivers regulated power supplies at +10V, −10V and +5V for the spacecraft's electronic systems with an overall efficiency of around 87 percent.

The average power available to the spacecraft electronic systems per orbit is around 8 Wdc.

General Data Beacon

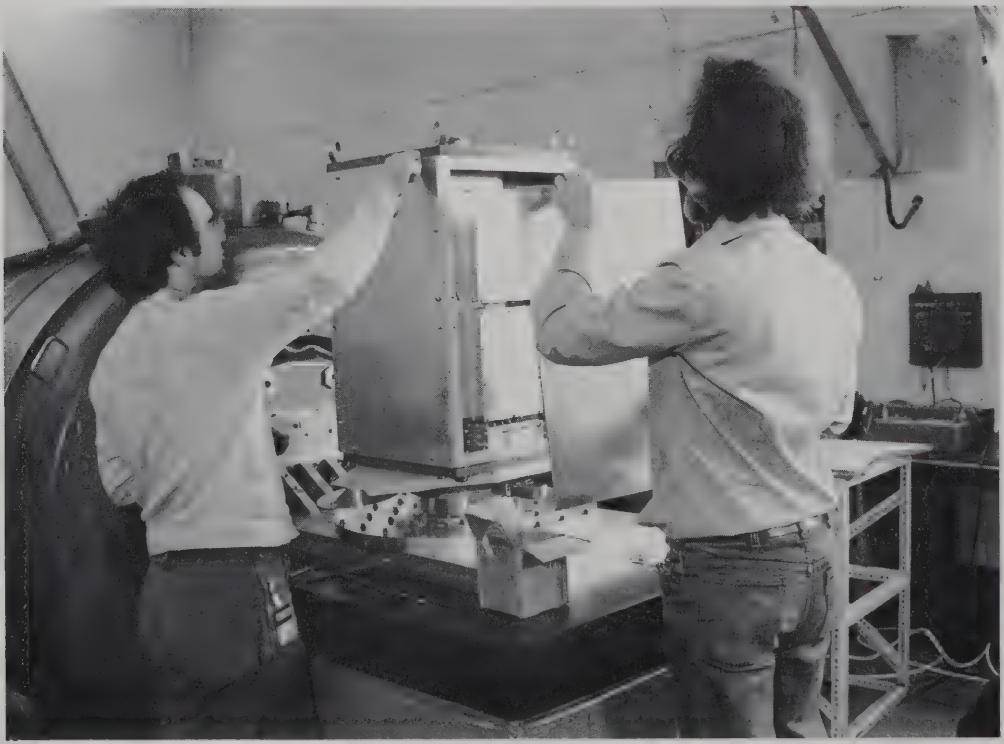
A 450 mW beacon operating at 145.825 MHz will provide the prime interface from the spacecraft to the outside world. This beacon has been specifically designed to provide a healthy satellite-to-ground transmission link enabling reliable reception by the simplest of amateur ground stations. The modulation form will be nbfm and, in order to minimize Doppler tracking, data will be transmitted as afsk. The transmissions will be compatible with standard, unmodified amateur nbfm receivers and a small, fixed, crossed-dipole receiving antenna should suffice for all but the lowest elevation orbits. A low-cost audio data demodulator will be required to interface with a printer/display, details of which will be published. The beacon can also be modulated by speech from the Synthesized Speech Telemetry Experiment and data from the earth-pointing camera.

The data sources available to this beacon are:

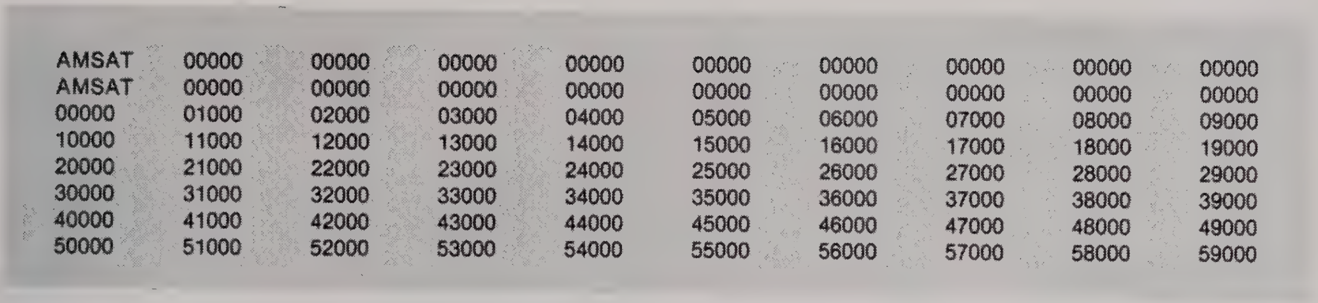
- 1200 baud ASCII Telemetry
- 300 baud ASCII Telemetry
- 110 baud ASCII Telemetry
- 45.5 baud BAUDOT Telemetry
- 12 wpm Morse code Telemetry
- synthesized speech telemetry
- spacecraft computer asynchronous interface
- earth imaging system data

Engineering Data Beacon

A 400 mW beacon operating at 435.025 MHz is the primary spacecraft engineering data and high speed experimental data channel intended for advanced amateur ground stations, advanced scientific experimenters and the ground command station network. The modulation form will be bi-phase psk with the following data sources available:



UoSAT frame undergoes vibration tests.



```
AMSAT   00000   00000   00000   00000   00000   00000   00000   00000   00000
AMSAT   00000   00000   00000   00000   00000   00000   00000   00000   00000
00000   01000   02000   03000   04000   05000   06000   07000   08000   09000
10000   11000   12000   13000   14000   15000   16000   17000   18000   19000
20000   21000   22000   23000   24000   25000   26000   27000   28000   29000
30000   31000   32000   33000   34000   35000   36000   37000   38000   39000
40000   41000   42000   43000   44000   45000   46000   47000   48000   49000
50000   51000   52000   53000   54000   55000   56000   57000   58000   59000
```

Fig. 1 — The telemetry frame format to be used with UoSAT

- 1200 baud ASCII Telemetry
- 300 baud ASCII Telemetry
- 110 baud ASCII Telemetry
- 45.5 baud BAUDOT Telemetry
- spacecraft computer synchronous interface
- spacecraft computer asynchronous interface
- spacecraft computer output port
- earth imaging system data
- direct magnetometer data
- direct radiation counter data

Telecommand System

Direct and positive control over the spacecraft's on-board systems is essential for efficient mission management and to minimize potential interference both within the spacecraft and to external services. The complexity of the spacecraft and its operating modes are such that manual real-time control alone would present an irksome chore for telecommand station operators, and necessitate a comprehensive network of stations for maintaining day-to-day schedules. Two modes of control over the spacecraft are therefore available:

1) Direct, real-time control by the ground station network for:

- unscheduled command status changes
- command status initializations
- loading initial and modified software into the on-board microcomputer
- positive control of the spacecraft when in a partial failure mode
- simple command changes

2) Indirect, stored-program control of the spacecraft executed by an on-board microcomputer upon predetermined schedules or telemetry performance analysis, for:

- day-to-day scheduled operation
- spacecraft mode changes out of range of ground telecommand stations
- surveillance of on-board telemetry and executive control in event of spacecraft emergency

Positive control over the spacecraft is assured by allowing overriding precedence to control data emanating from direct ground telecommand. This includes total shut-down of the on-board microcomputer.

The spacecraft computer will employ the same command decoding and distribution system as the direct command mechanism and will behave as a local "ghost" telecommand station feeding scheduled commands into the command decoder according to a programmed diary.

Telemetry System

Knowledge of the status and performance of the spacecraft systems is similarly essential for efficient mission management and to ensure longevity of the spacecraft's operation. Sensors located around the spacecraft will monitor parameters such as temperature, voltage or current which are then encoded and made available, in addition to various other processed data, to a downlink beacon via a telemetry module. The basic philosophy of the telemetry system is to provide both a comprehensive surveillance of the on-board systems for engineering purposes and a wide selection of data formats to cater for differing ground station facilities.

The telemetry frame comprises sixty uniquely addressed analogue channels with forty status flags and an identifier. The analogue channels range from 000 to 999 thus giving a maximum data resolution of 0.1 percent. At the highest data rate (1200 baud) each telemetry frame takes some 8 seconds to be transmitted which is somewhat less frequent than the experimental instrument sample rate, thus instrument data is time-averaged and presented within the telemetry frame. (High time-resolution experimental data is available via the spacecraft computer for more detailed analysis.) The telemetry frame format will be as shown in Fig. 1.

On-Board Experiments

In line with the mission objective UoSAT will contain the following experiment complement:

Propagation Studies Experiments

- Phase referenced hf beacons at about 7 MHz, 14 MHz, 21 MHz and 28 MHz enabling simple AOS obser-

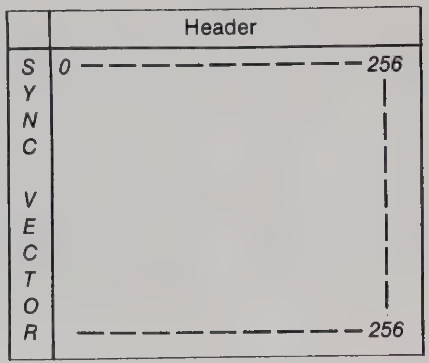


Fig. 2 — The format for an image display device.

vation to indicate ionospheric paths or more complex calculations yielding ionospheric electron densities.

- A three-axis, wide-range, flux-gate magnetometer for the examination of the fine structure of the earth's magnetic field and any disturbances to it and their relationship to radio wave propagation. This data will be available on the General Data Beacon (145.825 MHz) and with higher resolution on the Engineering Data Beacon (435.025 MHz).

- Two particle radiation detectors and counters (detecting particles with energies <20 keV and <60 keV) providing real-time information on solar activity and auroral events. This data will be available on the General Data Beacon and with higher resolution on the Engineering Data Beacon.

- Two microwave beacons on 2.4 GHz and 10.47 GHz to study S.H.F. propagation and the problems associated with inexpensive microwave satellite ground equipment.

Education Experiments

- An earth-pointing, solid-state, charge-coupled-device (CCD) camera will provide land and sea image data for transmission to simple and inexpensive ground stations via the General Data Beacon using fm synchronous afsk at 1200 bps - line synchronous. The image format will be presented as a 256 x 256 pixcel digital array with each pixcel having 16 possible digital grey levels. The entire image will be transmitted to the ground in around 3½ minutes and can be stored in a solid state memory and displayed on a domestic television screen. The ground image area will be approximately 500 km x 500 km, providing a resolution of some 2 km on the earth's surface. The cost of the data demodulator, image memory and display electronics is around $240 and it is anticipated that modules and kits will be made commercially available. A microcomputer containing a video graphics card could also be used as the image display device. The format of the data is shown in Fig. 2. It may be possible to use this visual display experiment to present processed telemetry and experimental data in a graphical format.

- Telemetered data from the spacecraft and its experiments will be available at a variety of speeds and formats to cater for a wide range of ground station complexity.

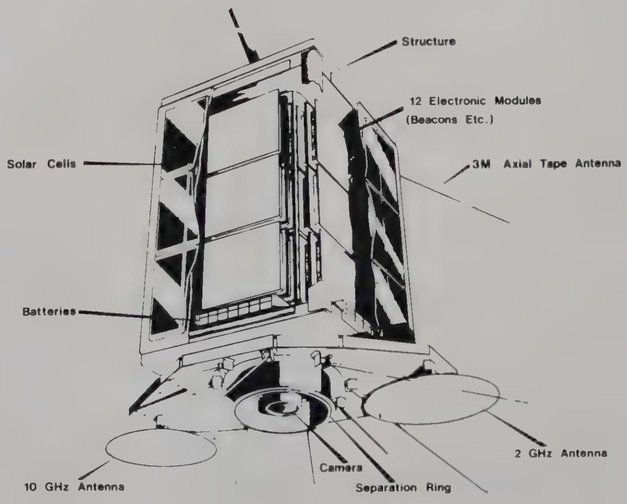
- A limited repertoire of telemetry will also be available in synthesized speech for transmission on the General Data Beacon intended for direct reception by the simplest standard nbfm equipment employing no more than a crossed dipole aerial.

Future Systems Experiments

- A combination of active and passive attitude control mechanisms based on gravity gradient stabilization and three-axis electromagnetic (magnetorquer) attitude adjustment will be evaluated. The spacecraft is designed to "fly" with the −z facet (bottom) always pointing toward the earth. This facet will support the camera and the vhf, uhf and microwave aerials.

- The 2.4 GHz and 10.47 GHz beacons will be used to evaluate the usefulness of these frequencies for future amateur spacecraft in conjunction with relatively simple and inexpensive ground stations.

- A powerful on-board CMOS microcomputer will have access to the spacecraft experiments, telemetry and command systems enabling:
  - Telemetry surveillance
  - Command and status management
  - Experiment data store and processing (eg: image processing, data reduction)
  - Orbit data, operational schedules and general news dissemination
  - Attitude control



A diagram of UoSAT hardware placement.

The spacecraft computer is based around the RCA CMOS CDP 1802 micro-processor and has direct data links with the magnetometer and radiation detectors experiments. This enables fast sampling of experimental data yielding fine time-resolution structure of these fields. The on-board computer also interfaces directly with the speech synthesizer experiment which can be fed with processed telemetry, experiment data or plain text. Analysis of navigation information from the magnetometer (using it as a coarse sensor and correlating with an existing model of the earth's magnetic field) will allow closed-loop attitude control employing the three-axis magnetorquers.

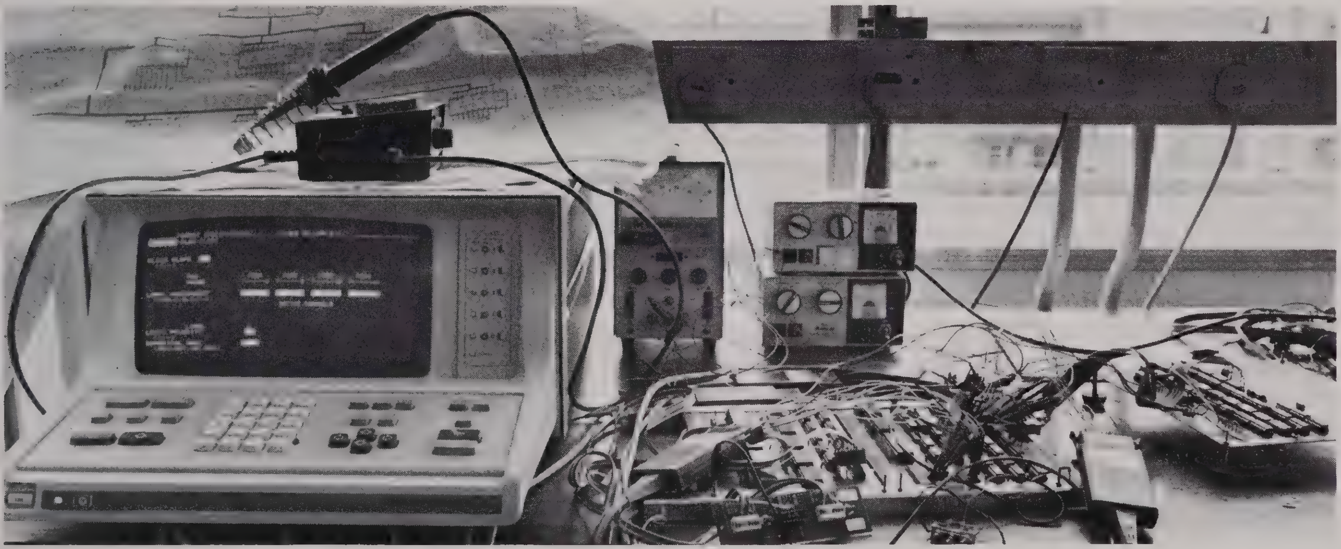
The spacecraft computer will have access to the telecommand decoder input in parallel with, but on a secondary basis to, the direct ground command receiver. Control data emanating from ground stations will have priority over locally generated control data at all times and the computer will have positive shut-down by ground command in the event of computer malfunction. The computer will be capable of generating the appropriate command repertoire locally as directed by software resident in its memory. This software is loaded from the ground by command stations using the Telecommand uplink channel. The entire software library resident in the spacecraft computer can be modified or replaced during flight by ground telecommand stations, in order to accommodate changes in the mission profile and to allow for the correction of possible software or hardware failures.

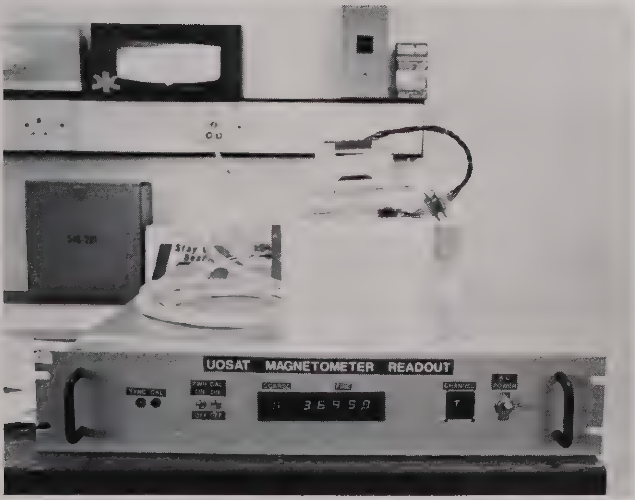
Orbit

UoSAT is currently scheduled for launch by NASA into a sun-synchronous, polar, earth orbit in September 1981 as a secondary payload upon a DELTA 2310 launch vehicle accompanying the Solar Mesosphere Explorer (S.M.E.) spacecraft. The programmed orbital elements are as follows:

Altitude: 530 km
Period: 95 minutes
Inclination: 97.5 degrees, sun-synchronous, 3 P.M. descending node.

The orbital life-time of the spacecraft at this altitude is expected to be around four and a half years before reentry.





UoSAT circuitry lab development equipment

A Calculator For Pre-setting Your Satellite Clock

By Kaz J. Deskur, K2ZRO*

Most OSCAR users employ a dedicated clock to count the elapsed minutes after the equatorial crossing (EQX) of the satellite. This facilitates the use of orbital calculators or listings that indicate the position of the satellite in terms of minutes after EQX.

Being in the shack at the time the satellite crossed the equator for the sole purpose of setting the satellite clock to zero minutes is not always convenient. Therefore, many resort to pre-setting the satellite clock well ahead of time so it will indicate zero minutes at the instant the satellite crosses the equator. Of course, this method works well, but it requires a certain amount of "mental strain" (subtractions, using a numbering system with a base of 60) and, therefore, it is prone to mistakes.

This device consists of two similarly marked concentric scales pivoted at their centers. Both scales are divided into 60 equal segments each representing a one-minute interval. The outer scale represents the *Orbital Time* or minutes after EQX. The inner scale represents the *Real Time*, namely the actual minutes after the hour as read on your wrist watch.

One can build a device by making two tracings), cementing them to a stiff paper, cutting out the inner scale; and then, fastening them to each other with a rivet, screw or thumbtack.

Here is how to use it:

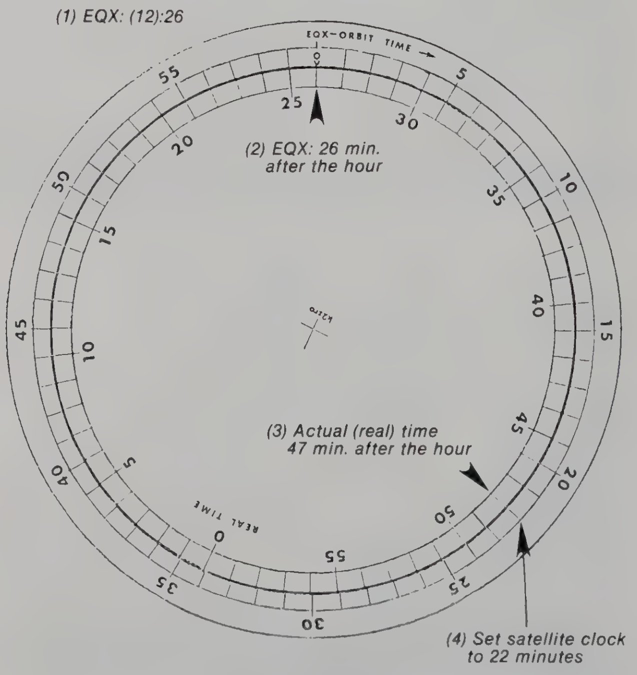
1) From an orbital calendar determine the EQX of the desired orbit. Ignore the hour, just note the minutes after the hour. Follow the example given in the diagram

2) Set "0" minutes (EQX) of the *Orbital Time* scale against the EQX time as read on the *Real Time* scale. (Example: EQX 12:26; set "0" (EQX) on outer scale against "26" on the inner scale. This means that EQX will occur at 26 minutes after the hour of the *Real Time*.)

3) Read the actual minutes after the hour on your station clock and find it on the *Real Time* (inner) scale. (Example: the actual time is 11:47)

4) Set the satellite clock to the value of *Orbital Time* that is lined up with the *Real Time*. (Example: :47 minutes of the *Real Time* corresponds to 22 minutes of *Orbital Time*. Set the satellite clock to 22.)

Now the satellite clock will pass through 0 minutes at exactly EQX time (36 minutes after the hour in our example). For those that don't have the satellite clock, the calculator provides easy conversion of the *Real Time* into *Orbital Time*. Set the device as described above; then after the EQX occurs, relate the minutes after Equatorial Crossing (outer scale) to the *Real Time* (indicated on the inner scale).



(1) EQX: (12):26

(2) EQX: 26 min. after the hour

(3) Actual (real) time 47 min. after the hour

(4) Set satellite clock to 22 minutes

A half-size photo reduction of K2ZRO's original calculator. See the text for details.

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BASIC Orbits

(Continued from page 11)

```
10  DIM T$(20),S$(40),I$(40),C(3,2) \ P=0 \ REM--P=Page # counter
20  REM--C8$=Page-separator $tring (could be form-feed) for your printer--
30  C8$=CHR$(10)+CHR$(10)+CHR$(10)+CHR$(10) \ REM--4 line feeds
40  REM--C9$=Clear CRT screen and beep for prompt--
50  C9$=CHR$(12)+CHR$(7) \ PRINT C9$ \ REM--AMS80+VDB4 compatible
60  PRINT" AMSAT ORBITAL PREDICTION PROGRAM de W3IWI -- May,1980"
70  PRINT" COPYRIGHT 1980 by Dr. Thomas A. Clark, W3IWI"
80  PRINT"                   6388 Guilford Road"
90  PRINT"                   Clarksville, MD 21029"
100 PRINT" Permission granted for non-commercial use providing"
110 PRINT" credit is given to the author, AMSAT and ORBIT Magazine."
120 PRINT
130 REM ***** Set starting Day/Time, duration & step size & initialize *****
140  INPUT1 "Start: Year = ",Y \ Y=Y/100 \ Y=INT(100* (Y-INT(Y)) + .1)
150   IF Y/4=INT(Y/4) THEN F9=1  ELSE F9=0 \ REM--F9=Leap-year flag
160  INPUT1 "   Month (1-12) = ",M \ INPUT1 "   Day = ",D
170  T$=FNT$(Y) + "/" + FNT$(M) + "/" + FNT$(D) + " at " \ REM--For printing
180  REM--Calculate D8=Day# (Note that month #13 = January of following year)
190   RESTORE 930 \ FOR I=1 TO M \ READ D9 \ NEXT \ D8=D+D9
200   IF M>2  THEN D8=D8+F9 \ PRINT "     Day #",D8 \ PRINT
210  INPUT1"Start: UTC  Hours = ",H
220  INPUT "    Min. = ",M \ T7=D8 + H/24 + M/1440
230  T$=T$ + FNT$(H) + FNT$(M) + ":00" \ REM--For printing
240  INPUT1"Duration:   Hours = ",H1
250  INPUT "    Min. = ",M1\ T8=T7 + H1/24 + M1/1440
260  INPUT1"Time Step:   Min. = ",M2 \ T9=M2/1440
270  PRINT %10F4,"     From ",T7," to ",T8 \ PRINT
280  INPUT "Output Unit # ",P9 \ IF P9<>0 THEN C9$=C8$
290  RESTORE 950 \ READ P1,C,R0,F,G0,G1 \ REM--Get physical constants
300   P2=2*P1 \ P0=P1/180 \ F=1/F
310   READ Y1,G2 \ IF Y1=Y THEN 330  ELSE IF Y1>0 THEN 310
320   PRINT "Unable to find Year ",Y," in Sidereal Time Table" \ STOP
330  RESTORE 1090 \ READ L9,W9,H9,C$,E8 \ REM--Get station data
340  D=FNO(D) \ GOSUB 860 \ REM--Call to FNO initializes observer's vector
350 REM ****** Select parameters for satellite of interest ******
360  PRINT "SATELLITE SELECTION MENU" \ I=0 \ RESTORE 1120 \ PRINT
370   READ S$ \ IF S$="END" THEN 400 ELSE READ I$ \ I=I+1
380   PRINT "Entry #",I," for ",S$ \ PRINT "   ID = ",I$
390   READ D,D,D,D,D,D,D,D,D,D,D,D,D,D \ GOTO 370 \ REM--D's are dummy
400  INPUT "Select Entry # ",J \ RESTORE 1120 \ REM--Get the satellite data
410   IF J<1 OR J>I THEN 400 \ REM--Hiccup if invalid entry requested
420  FOR I=1 TO J \ READ S$,I$,Y3,D3,H3,M3,S3
430   READ K0,M0,N0,A0,I0,E0,W0,O0,F1 \ NEXT
440  PRINT \ PRINT "Doppler calculated for freq = ",F1," MHz"
450  INPUT " Change frequency to (0 for default) ",D
460   IF D<>0 THEN F1=D
470  IF Y3=Y THEN 500 ELSE PRINT "ELEMENTS NOT FROM CURRENT YEAR" \ STOP
480  REM--IF D3 is an Integer then epoch is assumed to be in HH,MM,SS Format,
490   REM    or IF D3 is not Integer, then D3 is epoch in days + fractions
500   IF D3=INT(D3) THEN T0=D3 + H3/24 + M3/1440 + S3/86400  ELSE T0=D3
510 PRINT#P9 \ PRINT#P9,"Orbital Elements for ",S$ \ REM--Print out summary--
520  PRINT#P9,"       Reference ID= ",I$ \ PRINT#P9
530  PRINT#P9,"Reference Epoch = ",Y3," +",T0
540  PRINT#P9,"Starting  Epoch = ",Y," +",T7," = ",T$
550  PRINT#P9
560  PRINT#P9,"Parameter",TAB(20),"Reference",TAB(40),"Starting"
570   T=T7 \ D=FNC(T) \ D=FNM(T) \ REM--Dummy calls to FNC & FNM to initialize
580  PRINT#P9,"Orbit Number ",TAB(20),K0,TAB(40),K
590  PRINT#P9,"Mean Anomaly ",TAB(20),M0,TAB(40),M/P0
600  PRINT#P9,"Inclination  ",TAB(20),I0
610  PRINT#P9,"Eccentricity ",TAB(20),E0
620  PRINT#P9,"Mean Motion  ",TAB(20),N0
630  PRINT#P9,"S.M.A.,km    ",TAB(20),A0
640  PRINT#P9,"Arg. Perigee ",TAB(20),W0,TAB(40),W
650  PRINT#P9,"R. A. A. N.  ",TAB(20),O0,TAB(40),O
660  PRINT#P9,"Freq.,MHz    ",TAB(20),F1 \ K9=9E9 \ K8=9E9
670 REM ****** Here follows the actual computation loop ******
680  FOR T=T7 TO T8 STEP T9 \ K7=INT(T) \ D=FNM(T)
690  REM--New orbit? If so, update the a priori values for W & O for new orbit
700   IF K=K9 THEN 720 \ D=FNC(T) \ K8=9E9 \ K9=9E9
710  REM--Above Elevation limit?  New date?
720   D=FNK(M) \ D=FNX(T) \ IF E9<E8 THEN 830 \ IF K7=K8 AND K9=K THEN 770
730    IF K=K9 THEN 760  ELSE GOSUB 860 \ K9=K
740  PRINT#P9," U.T.C.    AZ    EL  DOPPLER  RANGE   HEIGHT   LAT  LONG  PHASE"
750  PRINT#P9,"HHMM:SS   deg   deg    Hz       km       km    deg   deg  <256>"
760  PRINT#P9,TAB(10),"- - - DAY #",K7," - - - ORBIT #",K," - - -"
770  K8=K7 \ T4=T-K7 \ S4=INT(T4*86400 + .5) \ H4=INT(S4/3600 + 1E-6)
780  M4=INT((S4 - H4*3600) / 60 + 1E-6) \ S4=S4 - 3600*H4 - 60*M4
790  T$=FNT$(H4) + FNT$(M4) + ":" + FNT$(S4) \ REM--Printable time string
800  F9=-F1*1E6 * R8/C \ REM--F9=Doppler(Hz)=Frequency * Velocity/C
810  PRINT#P9,T$, %6I,FNI(A9),FNI(E9), %7I,FNI(F9), \ REM--CONTINUES....
820   PRINT#P9, %9I,FNI(R5),FNI(R-R0), %6I,FNI(L5),FNI(W5),M9
830  NEXT \ PRINT \ INPUT "PRESS RETURN TO CONTINUE ",D$ \ GOTO 50
840 REM ------------------------------
850 REM ****** Page header subroutine ******
860  PRINT#P9,C9$,C$,"  Lat.=",L9,"  W.Long.=",W9,"  Ht.=",H9,
870  P=P+1 \ PRINT#P9,TAB(54),"Pg. #",P
880  PRINT#P9,TAB(10),"- - - Minimum Elevation =",E8," Deg. - - -"
890  PRINT#P9 \ RETURN
900 REM ------------------------------
910 REM ****** Numerical and Physical Constants ******
920 REM--Day# at start of each month (Thirty days hath Septober ...)
930     DATA 0,31,59,90,120,151,181,212,243,273,304,334,365
940 REM--Pi, Velocity of Light, Earth Radius, 1/Earth flattening coefficient
950     DATA 3.1415926535 , 2.997925E5 , 6378.160 , 298.25
960 REM--GM of Earth in (Orbits/day)↑2/km↑3 and Sidereal/Solar Time rate ratio
970     DATA 7.5369793E13 , 1.0027379093
980 REM--Greenwich Sidereal Times on Jan 0.0 in days for 1979 thru 1985
990     DATA 79 , 0.2751843198
1000    DATA 80 , 0.2745212008
1010    DATA 81 , 0.2765959911
1020    DATA 82 , 0.2759328721
1030    DATA 83 , 0.2752697531
1040    DATA 84 , 0.2746066342
1050    DATA 85 , 0.2766814244
1060    DATA 0,0 \ REM ****** Terminates Sidereal Time table ******
1070 REM ------------------------------
1080 REM--Station data--Lat.&W.Long.(Deg),Height(Meters),Call & Min.Elevation
1090    DATA 39.185 , 76.936 , 150 , "W3IWI" , -3
1100 REM ------------------------------
```

```
1110 REM ****** Sample satellite information tables now follow ******
1120  DATA "Phase-3 Transfer Orbit"
1130  DATA "Initial pre-launch guess"
1140   DATA 80 , 144 , 12 , 15 , 00 \ REM--Epoch (Y,Day#,H,M,S)
1150   DATA 0          \ REM--Orbit # at epoch
1160   DATA 0          \ REM--Mean Anomaly at epoch
1170   DATA 0 , 24364  \ REM--Mean Motion OR Semi-major axis
1180   DATA 17.5       \ REM--Inclination
1190   DATA 0.730      \ REM--Eccentricity
1200   DATA 189.7      \ REM--Arg. of Perigee
1210   DATA 212.35     \ REM--R.A.A.N. (for 1200 UTC launch on May 23,1980)
1220   DATA +145.81    \ REM--Gen'l Beacon freq, MHz for Doppler Calculation
1230 REM ------------------------------
1240  DATA "Phase-3 Final Orbit"
1250  DATA "Initial pre-launch guess"
1260   DATA 80 , 153 , 00 , 00 , 00 \ REM--Epoch (Y,Day#,H,M,S)
1270   DATA 10000      \ REM--Orbit # at epoch (DUMMY)
1280   DATA 0          \ REM--Mean Anomaly at epoch
1290   DATA 0 , 25028  \ REM--Mean Motion OR Semi-major axis
1300   DATA 56         \ REM--Inclination
1310   DATA 0.6852     \ REM--Eccentricity
1320   DATA 200        \ REM--Arg. of Perigee
1330   DATA 0          \ REM--R.A.A.N.(DUMMY)
1340   DATA +145.81    \ REM--Gen'l Beacon freq, MHz
1350 REM ------------------------------
1360  DATA "AMSAT-OSCAR-7"
1370  DATA "NASA BLTN 376"
1380   DATA 80 , 097.5080185 ,0,0,0 \ REM--Epoch (Y,Day#+fraction,Zeroes)
1390   DATA 24665      \ REM--Orbit # at epoch
1400   DATA 354.8114   \ REM--Mean Anomaly at epoch
1410   DATA 12.53338432,0 \ REM--Mean Motion OR Semi-major axis
1420   DATA 101.4520   \ REM--Inclination
1430   DATA 0.0011786  \ REM--Eccentricity
1440   DATA 005.3080   \ REM--Arg. of Perigee
1450   DATA 125.3892   \ REM--R.A.A.N.
1460   DATA -286.20    \ REM--Mode-B Transponder Equivalent Freq, MHz.
1470 REM ------------------------------
1480  DATA "Phase-3 Final Orbit"
1490  DATA "As it actually happened"
1500   DATA 80 , 144 , 14 , 30 , 00 \ REM--Epoch (Y,Day#,H,M,S)
1510   DATA 0          \ REM--Orbit # at epoch
1520   DATA 0          \ REM--Mean Anomaly at epoch
1530   DATA 0 , 99999  \ REM--Mean Motion OR Semi-major axis
1540   DATA 5          \ REM--Inclination
1550   DATA .936252    \ REM--Eccentricity
1560   DATA 90         \ REM--Arg. of Perigee
1570   DATA 317        \ REM--R.A.A.N.
1580   DATA -00.000    \ REM--The Gen'l Beacon freq, MHz actually achieved
1590 REM ------------------------------
1600  DATA "SRET-2 in Phase-3 type orbit"
1610  DATA "Data de ZS1BI -08 Feb 81"
1620   DATA 81 , 034.3206 ,0,0,0 \ REM--Epoch (Y,Day# + fraction)
1630   DATA 0          \ REM--Orbit # at epoch (un-specified)
1640   DATA 043.5718   \ REM--Mean Anomaly at epoch
1650   DATA 1.9554590 , 0 \ REM--Mean Motion OR Semi-major axis
1660   DATA 64         \ REM--Inclination
1670   DATA .735632    \ REM--Eccentricity
1680   DATA 276.270    \ REM--Arg. of Perigee
1690   DATA 297.2970   \ REM--R.A.A.N.
1700   DATA 137.530    \ REM--Beacon Frequency, MHz
1710 REM ------------------------------
9000   DATA "END"      \ REM ***** Terminates satellite information table *****
9010 REM ------------------------------
10000 REM ****** ORBIT DETERMINATION AND UTILITY ROUTINES ******
10010 DEF FNA(X,Y)
10020  REM--Calculates INVERSE TANGENT in proper quadrant, just like
10030    REM      the FORTRAN ATAN2 function.
10040  REM--Cases lying in Quadrants 2&3--
10050   IF X<0 THEN RETURN P1 + ATN(Y/X)   ELSE IF X>0 THEN 10090
10060  REM--The two cases for X=0--
10070   IF Y>=0 THEN RETURN P1/2  ELSE RETURN 3*P1/2
10080  REM--Cases lying in Quadrants 1&4--
10090   IF Y>=0 THEN RETURN ATN(Y/X)  ELSE RETURN P2 + ATN(Y/X)
10100 FNEND ------------------------------
10110 DEF FNC(T)
10120  REM--Routine to initialize the C(J,K) coordinate rotation matrix
10130    REM    and other parameters associated with the orbital elements.
10140  IF N0 > 0.1 THEN A0=((G0 / (N0↑2)) ↑ (1/3)) \ REM--Given N0=Mean Motion
10150  IF N0 <= 0.1 THEN N0=SQRT(G0 / (A0↑3)) \ REM--Given A0=Semi-major axis
10160  E2=1-E0↑2 \ E1=SQRT(E2) \ Q0=M0/360 + K0 \ REM--Q0=Initial orbit phase
10170  REM--Account for nodal effects due to lumpy gravity field due to the
10180    REM    flattened, oblate spheroidal, figure of the earth
10190   K2=9.95 * ((R0/A0)↑3.5) / (E2↑2)
10200  REM--Update elements to current epoch & evaluate their SIN/COS's
10210   S1=SIN(I0*P0) \ C1=COS(I0*P0) \ REM--I0=Inclination (deg)
10220   O=O0 - (T-T0) * K2 * C1
10230    S0=SIN(O*P0) \ C0=COS(O*P0) \ REM--O=R.A.A.N. (degrees)
10240   W=W0 + (T-T0) * K2 * (2.5 * (C1↑2) - .5)
10250    S2=SIN(W*P0) \ C2=COS(W*P0) \ REM--W=Argument of Perigee (degrees)
10260  REM--Set up coordinate rotation matrix for the current orbit
10270   C(1,1)= + (C2*C0) - (S2*S0*C1) \ C(1,2)= - (S2*C0) - (C2*S0*C1)
10280   C(2,1)= + (C2*S0) + (S2*C0*C1) \ C(2,2)= - (S2*S0) + (C2*C0*C1)
10290   C(3,1)= + (S2*S1)              \ C(3,2)= + (C2*S1)  \  RETURN 0
10300 FNEND ------------------------------
10310 DEF FNM(T)
10320  REM--Function to evaluate M=MEAN ANOMALY in (0-2*PI) range,
10330    REM      K=Perigee Passage Kounter (=Orbit ##) & M9=modulo 256
10340    REM      orbital phase compatible with General Beacon telemetry.
10350   Q=N0*(T-T0)+Q0 \ K=INT(Q) \ M9=INT((Q-K)*256) \ M=(Q-K)*P2 \ RETURN 0
10360 FNEND ------------------------------
10370 DEF FNK(M)
10380  REM--Routine to solve KEPLER's equation given M & return
10390    REM      the Satellite's GEOCENTRIC coordinates.
10400   E=M + E0*SIN(M) + .5 * (E0↑2) * SIN(2*M) \ REM--Initial trial value
10410  REM--Iteration loop to solve trancendental Kepler's equation--
10420   S3=SIN(E) \ C3=COS(E) \ R3=1 - E0*C3 \ M1=E - E0*S3
10430   M5=M1-M \ IF ABS(M5) < 1E-6 THEN 10450  ELSE E=E - M5/R3 \ GOTO 10420
10440  REM--Now get satellite's XYZ coordinates--
10450   X0=A0*(C3-E0) \ Y0=A0*E1*S3 \ R=A0*R3 \ REM--In the plane of the orbit
10460  REM--Rotate from Orbit plane to INERTIAL CELESTIAL Coordinates.
10470  X1=X0*C(1,1)+Y0*C(1,2) \ Y1=X0*C(2,1)+Y0*C(2,2) \ Z1=X0*C(3,1)+Y0*C(3,2)
10480  REM--Rotate thru current GHA of ARIES, convert to GEOCENTRIC coordinates
10490   G7=T*G1 + G2 \ G7=(G7-INT(G7)) * P2 \ S7=-SIN(G7) \ C7=COS(G7)
10500   X= + (X1*C7) - (Y1*S7) \ Y= + (X1*S7) + (Y1*C7) \ Z=Z1 \ RETURN 0
10510 FNEND ------------------------------
```

```
10520 DEF FNO(D)
10530  REM--Routine to evaluate OBSERVER's GEOCENTRIC coordinates,
10540   REM     where X-axis=GREENWICH, Y-axis=VU-land & Z-axis=North pole.
10550  L8=L9*P0 \ S9=SIN(L8) \ C9=COS(L8) \ REM--Initial GEODETIC coordinates
10560   S8=SIN(-W9*P0) \ C8=COS(W9*P0) \ REM--W9=West Longitude
10570  REM--Following accounts for flattened oblate spheroidal earth--
10580   R9=R0*(1 - (F/2) + (F/2) *COS(2*L8)) + H9/1000 \ REM--H9=height(meters)
10590  REM--Following makes L8 be the GEOCENTRIC latitude--
10600   L8=ATN( (1-F)↑2 * S9/C9 ) \ Z9=R9 * SIN(L8)
10610   X9=R9 * COS(L8) * C8 \ Y9=R9 * COS(L8) * S8 \ RETURN 0
10620 FNEND -----------------------------
10630 DEF FNX(T)
10640  REM--Routine to extract all the parameters you might ever need.
10650  REM     First get vector from observer to satellite--
10660   X5= (X-X9) \ Y5= (Y-Y9) \ Z5= (Z-Z9) \ R5=SQRT(X5↑2 + Y5↑2 + Z5↑2)
10670  REM--Finite difference the range (R5) to get the velocity (R8)--
10680   IF T6<>T THEN R8=((R6-R5)/(T6-T)) / 86400   ELSE R8=-9E9
10690   R6=R5 \ T6=T \ REM--& Save current range & time for next time thru
10700  REM--Now rotate into OBSERVER's LOCAL coordinates
10710    REM    where X8=North, Y8=East & Z8=Up (Left-Handed system!)
10720   Z8= + (X5*C8*C9) + (Y5*S8*C9) + (Z5*S9)
10730   X8= - (X5*C8*S9) - (Y5*S8*S9) + (Z5*C9) \ Y8= + (Y5*C8) - (X5*S8)
10740   S5=Z8/R5 \ C5=SQRT(1-S5*S5) \ E9=ATN(S5/C5) / P0 \ REM--E9=Elevation
10750   A9=FNA(X8,Y8) / P0 \ REM--FNA resolves correct quadrant for A9=Azimuth
10760   W5=360-FNA(X,Y) / P0 \ REM--W5=Sub-Satellite Point (SSP) W.Longitude
10770   B5=Z/R \ L5=ATN(B5 / (SQRT(1 - B5↑2))) / P0 \ REM--L5=SSP Latitude
10780  RETURN 0 \ REM--Note R-R0=Satellite's altitude above mean spheroid.
10790 FNEND -----------------------------
10800 REM--FNT$ Returns two character printable string corresponding to D--
10810  DEF FNT$(D) =  CHR$(48 + INT(D/10)) + CHR$(48 + D - 10 * INT(D/10))
10820 REM -----------------------------
10830 REM--FNI Rounds to nearest integer, accounting for sign--
10840  DEF FNI(D)=SGN(D) * INT (ABS(D) + .5)
10850 REM -----------------------------
19999 END
```

Sample Run:

```
 AMSAT ORBITAL PREDICTION PROGRAM de W3IWI -- May,1980
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                  Clarksville, MD 21029
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Start: Year = 80   Month (1-12) = 5   Day = 23     Day # 144

Start: UTC  Hours = 23    Min. = 00
Duration:   Hours = 12    Min. = 00
Time Step:   Min. = 15     From   144.9583 to   145.4583

Output Unit # 0



W3IWI  Lat.= 39.185  W.Long.= 76.936  Ht.= 150        Pg. # 1
          - - - Minimum Elevation = -3 Deg. - - -

SATELLITE SELECTION MENU

Entry # 1 for Phase-3 Transfer Orbit
   ID = Initial pre-launch guess
Entry # 2 for Phase-3 Final Orbit
   ID = Initial pre-launch guess
Entry # 3 for AMSAT-OSCAR-7
   ID = NASA BLTN 376
Entry # 4 for Phase-3 Final Orbit
   ID = As it actually happened
Entry # 5 for SRET-2 in Phase-3 type orbit
   ID = Data de ZS1BI -- 18 Jan 81
Select Entry # 1

Doppler calculated for freq =  145.81 MHz
 Change frequency to (0 for default) 0

Orbital Elements for Phase-3 Transfer Orbit
       Reference ID= Initial pre-launch guess

Reference Epoch =  80 + 144.51041666667
Starting  Epoch =  80 + 144.95833333333 = 80/05/23 at 2300:00

Parameter            Reference          Starting
Orbit Number          0                  1
Mean Anomaly          0                  8.108205410808
Inclination           1/.5
Eccentricity          .73
Mean Motion           2.282841583977
S.M.A.,km             24364
Arg. Perigee          189.7              190.03262384115
R. A. A. N.           212.35             212.17117265205
Freq.,MHz             145.81


W3IWI  Lat.= 39.185  W.Long.= 76.936  Ht.= 150        Pg. # 2
          - - - Minimum Elevation = -3 Deg. - - -

 U.T.C.    AZ    EL  DOPPLER  RANGE  HEIGHT   LAT  LONG  PHASE
HHMM:SS   deg   deg    Hz      km      km     deg   deg  <256>
          - - - DAY # 144 - - - ORBIT # 1 - - -
2315:00   196     1   -901   10407    5973   -17    91    11
2330:00   180    14  -1571   13315    9/02   -14    77    17
2345:00   171    20  -1616   16305   13082   -12    70    24
          - - - DAY # 145 - - - ORBIT # 1 - - -
0000:00   166    24  -1506   19092   16109   -11    66    30
0015:00   162    2/  -1367   21622   18821    -9    63    36
0030:00   161    30  -1231   23900   21253    -8    62    42
0045:00   160    32  -1105   25944   23436    -6    62    48
0100:00   160    34   -989   27774   25395    -5    62    54
0115:00   160    36   -882   29405   27147    -5    63    60
0130:00   161    37   -783   30855   28710    -4    64    66
0145:00   162    39   -691   32133   30095    -3    65    72
0200:00   164    40   -605   33252   31313    -2    66    78
0215:00   166    42   -523   34220   32373    -1    68    84
0230:00   168    43   -445   35043   33280    -1    69    90
0245:00   171    44   -370   35727   34041     0    71    9/
0300:00   173    45   -298   36278   34660     1    73   103
0315:00   176    46   -227   36698   35140     1    75   109
0330:00   179    47   -158   36990   35484     2    77   115
0345:00   182    47    -90   37157   35694     2    78   121
0400:00   186    48    -22   37197   35771     3    80   127
0415:00   189    48     46   37113   35715     4    82   133
0430:00   192    49    114   36903   35526     4    84   139
0445:00   196    49    182   36566   35204     5    86   145
0500:00   199    49    253   36098   34745     5    88   151
0515:00   202    49    324   35498   34148     6    89   157
0530:00   205    49    399   34760   33410     6    91   164
0545:00   208    49    476   33879   32527     7    93   170
0600:00   211    49    557   32848   31492     8    94   176
0615:00   213    48    643   31659   30299     8    96   182
0630:00   216    48    734   30302   28941     9    97   188
0645:00   218    48    832   28763   27407    10    98   194
0700:00   219    48    938   27027   25686    11    98   200
0715:00   220    48   1055   25074   23761    12    98   206
0730:00   221    49   1185   22881   21615    12    98   212
0745:00   220    49   1332   20416   19224    13    9/   218
0800:00   217    51   1498   17645   16559    15    95   224
0815:00   211    52   1684   14529   13585    16    91   231
0830:00   197    54   1876   11058   10263    17    84   237
0845:00   164    49   1944    7460    6583    17    71   243
0900:00   120     9    992    5623    2744    15    44 . 249

 PRESS RETURN TO CONTINUE


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Start: Year = 80   Month (1-12) = 5   Day = 23     Day # 144

Start: UTC  Hours = 14    Min. = 25
Duration:   Hours = 0    Min. = 20
Time Step:   Min. = 1     From   144.6007 to   144.6146

Output Unit # 0



W3IWI  Lat.= 39.185  W.Long.= 76.936  Ht.= 150        Pg. # 1
          - - - Minimum Elevation = -99 Deg. - - -

SATELLITE SELECTION MENU

Entry # 1 for Phase-3 Transfer Orbit
   ID = Initial pre-launch guess
Entry # 2 for Phase-3 Final Orbit
   ID = Initial pre-launch guess
Entry # 3 for AMSAT-OSCAR-7
   ID = NASA BLTN 376
Entry # 4 for Phase-3 Final Orbit
   ID = As it actually happened
Entry # 5 for SRET-2 in Phase-3 type orbit
   ID = Data de ZS1BI -- 18 Jan 81
Select Entry # 4

Doppler calculated for freq =  0 MHz
 Change frequency to (0 for default) 0

Orbital Elements for Phase-3 Final Orbit
       Reference ID= As it actually happened

Reference Epoch =  80 + 144.60416666666
Starting  Epoch =  80 + 144.60069444444 = 80/05/23 at 1425:00

Parameter            Reference          Starting
Orbit Number          0                  -1
Mean Anomaly          0                  359.65682535871
Inclination           5
Eccentricity          .936252
Mean Motion           .27453971322749
S.M.A.,km             99999
Arg. Perigee          90                 89.999705619228
R. A. A. N.           317                317.00014803591
Freq.,MHz             0



W3IWI  Lat.= 39.185  W.Long.= 76.936  Ht.= 150        Pg. # 2
          - - - Minimum Elevation = -99 Deg. - - -

 U.T.C.    AZ    EL  DOPPLER  RANGE  HEIGHT   LAT  LONG  PHASE
HHMM:SS   deg   deg    Hz      km      km     deg   deg  <256>
          - - - DAY # 144 - - - ORBIT # -1 - - -
1425:00   184   -12      0    3933     393     4    79   255
1426:00   175   -14      0    3864     254     5    74   255
1427:00   166   -16      0    3883     143     5    69   255
1428:00   156   -17      0    3992      62     5    63   255
1429:00   148   -19      0    4185      13     5    58   255
1430:00   140   -21      0    4451      -3     5    52   255


W3IWI  Lat.= 39.185  W.Long.= 76.936  Ht.= 150        Pg. # 3
          - - - Minimum Elevation = -99 Deg. - - -

 U.T.C.    AZ    EL  DOPPLER  RANGE  HEIGHT   LAT  LONG  PHASE
HHMM:SS   deg   deg    Hz      km      km     deg   deg  <256>
          - - - DAY # 144 - - - ORBIT # 0 - - -
1431:00   133   -22      0    4/77      13     5    46     0
1432:00   126   -23      0    5149      62     5    41     0
1433:00   121   -24      0    5557     143     5    35     0
1434:00   116   -25      0    5990     254     5    30     0
1435:00   112   -26      0    6441     393     4    25     0
1436:00   109   -27      0    6902     558     4    20     0
STOP IN LINE 10730
READY
```

(Continued on page 29)

AMSAT OSCAR 7 Between Sunlight and Shadow

By Juergen Raddatz, DL3ZK*

Translation by DL1XJ

The telemetry data received from AMSAT-OSCAR 7 in the last few years has indicated that an increase in internal temperature took place during the winter season when the satellite was passing over the Northern Hemisphere. This high internal temperature was accompanied by a growing number of anomalies in the satellite's electronic system, *e.g.* frequent switch-over from one mode to another, malfunction and complete break-down of the telemetry section and of the transmitter, etc. During the summer, when the satellite was cooler, operation returned back to normal.

While investigating into the possible causes of these anomalies it was soon surmised that the disturbances might have been caused by increased irradiation by the sun. A prolonged exposure to the sun-rays leads to an increased intake of energy (heat) by the satellite. Now, under ideal conditions a satellite in space should radiate the same amount of energy as it absorbs. This process is, however, influenced by the shape of the satellite, details of its construction and its actual surface. Hence, it is possible that in certain structural parts of the satellites an accumulation of energy will occur (it will get hot) which may lead to trouble, particularly, as far as semiconductors are concerned.

If the supposition as regards the cause of the anomalies is correct, it remains to prove that the AMSAT-OSCAR 7 spacecraft was in sun-light during the periods when the troubles occurred. This paper is intended as a contribution to clear up this problem.

Solar Cell Current as an Indication of Light

Whether the satellite is traveling through a sun-lit area can be readily determined by listening to the telemetry beacon. The four quadrants of the solar cells, when lit by the sun, each supply a separate current to the storage battery, the magnitude of which is indicated in the telemetry data. In Morse-Code telemetry the respective channels are channels 1 B, 1 C, 1 D and 2 A. If the satellite is passing through the shadow, "no current" is indicated by these four channels. For more than two years now the existence of solar cell current was invariably indicated over Europe, and at no time during this period was a "no-current" state signaled. Consequently, the AMSAT-OSCAR 7 spacecraft must have been constantly passing through sun-lit space, at least when flying over Europe, irrespective of day or night on the earth's surface. This conclusion proved to be perfectly correct and is subsquently confirmed mathematically.

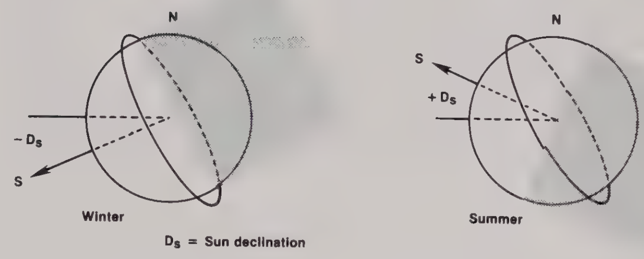


Fig. 1 — Simplified plot of the configuration of the earth shadow and the orbits of AMSAT OSCAR 7.

Satellite Orbit and Seasons

The position of the orbit of the AMSAT-OSCAR 7 spacecraft in relation to the earth shadow both for winter and summer seasons is shown in a somewhat simplified manner in Fig. 1. During winter when the sun culminates south of the equator (= negative sun declination), the satellite does not even touch the earth's shadow during a complete orbit from equator crossing to equator crossing, and is constantly flying in full sunlight, irrespective of prevailing day-time or night-time conditions at the location of the observer (QTH). The observer, the radio amateur, rotates with the earth beneath the seemingly "stationary" orbit line of the satellite; hence the observer's day/night relation to the sun is entirely different from that of the satellite. During our summer season (= positive sun declination) the satellite passes through the earth's shadow for certain periods and its temperature falls somewhat.

**Himmershoi 12, D-2391 Wees, Federal Republic of Germany*

It is, of course, possible to compute when and where the satellite crosses the terminator on each orbit and it is interesting to note that in the year 1979 all transitions into the earth shadow occur over the Southern hemisphere with a maximum latitude of about 40° South.

Calculation of the Shadow Height

When we restrict the question to whether in the course of a year (or on a certain day) the satellite touches the earth's shadow or not, the computations become much more simple, particularly if in the case of AMSAT-OSCAR 7 we assume a circular orbit having a median height of 1460 km.

The problem to be solved is first to find the height of the shadow above the earth's surface in the satellite's orbital plane. When the terminator is lower than the orbital height the spacecraft remains above the shadow zone and is exposed to the sun-light. If, on the other hand, the shadow zone extends to a region above the orbital height, the satellite must naturally cross the terminator and pass through the shadow zone. The height of the earth's shadow in the orbital plane is given by the following equation obtained from Bohrmann[1].

$$H = \frac{R}{\sin D_S \cos i - \cos D_S \sin i \sin (L_S - \Omega)} - R$$

Where:
H = *height of the earth shadow in the orbital plane (km)*

R = *median earth radius (6,371)*

i = *inclination (101.5° / summer 1979) (degrees)*

Ω = *right ascension of the satellite (degrees)*

D_S = *declination of the sun (Table) (degrees)*

L_S = *ecliptical longitude of the sun (degrees)*

A shadow curve for AMSAT-OSCAR 7 plotted from equation (1) for the year 1979 is shown in Fig. 2. It can be seen that between 19 April 1979 and 13 August 1979 the satellite passes through the earth shadow (over the Southern hemisphere) and will subsequently be flying in continuous sun-light until summer 1980 - with anticipated disturbances. The "shadow mountain" prevailing during summer over the median orbital height of the satellite will become smaller and smaller from each year. It will still surmount the orbital height of the satellite in 1980 but in 1981 when the satellite's orbital height and the shadow height become more or less equal AMSAT-OSCAR 7 will only be in shadow for very short periods. From 1983 onwards AMSAT-OSCAR 7 will fly in continuous sun-light for a long time.

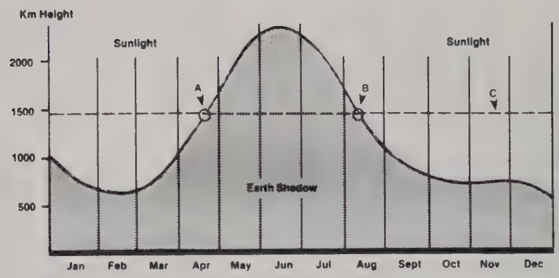


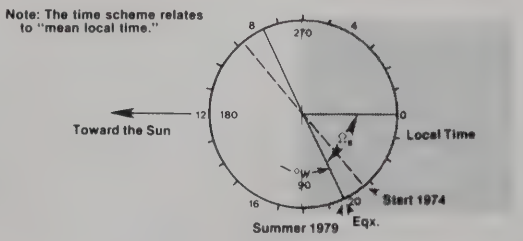
Fig. 2 — Height of the earth shadow above the earth's surface in the orbital plane of AMSAT OSCAR 7 during the year 1979. (A) April 19, 1979; (B) September 13, 1979; (C) Mean flight height.

The Solar Time Angle Ω_S

The calculation of the shadow height in the orbital plane using equation (1) presents some difficulty for the radio amateur since it requires the knowledge of certain data about the satellite and the sun orbit which are not readily available. The sun's coordinates can be looked up in astronomical year-books or taken from other tables of ephemerides but getting the right ascension data of the satellite is more difficult. Official measurement results are hard to come by, though it is quite feasible to obtain accurate values of right ascension by radio observations this procedure is rather time-consuming and cannot be recommended to the inexperienced.

A way out of this quandry is offered by the term "solar time angle" (Ω_S) which was introduced by the author and which can be easily determined from a list of equator crossings (EQX) (as accurate as possible). Such lists are universally in use by radio amateurs. The solar time angle Ω_S is then the angle between the ascending node (EQX) and the midnight meridian (shadow middle-line) as shown in Fig. 3. The numerical value of the solar time angle is obtained, by dividing the UTC-time of the equatorial crossing - expressed in minutes -by four and subtracting the result from the geographical longitude (West) of the respective crossing location. For example using the following W6PAJ orbit data: date -22 January 1979, orbit - 19 147, UTC -0112.2, degrees W - 79.2, 1 h 12.2 min = 72.2 min : 4 min/degree = 18.05 degrees and 79.2° - 18.05° = 61.15°. The solar time angle Ω_S amounted to 61.15° on 22 January 1979. It remains constant for all orbits.

Fig. 3 — Solar time angle.



The Time Equation

The rotation of the earth around its axis (diurnal rotation) is relative with respect to the fixed star sky, and its angular velocity is practically constant. This forms the basis of our measurement of time. In contrast, the annual revolution of the earth around the sun is not regular. The angular velocity varies because the orbit of the earth around the sun is not circular but is somewhat elliptical. A clock, following the sun over one year, would run faster at times and at times slower than normal.

Our conventional clocks, however, are designed to run at uniform speed, and to account for this state of affairs, the concept of a theoretical sun which exhibits constant angular velocity was "invented". This is the so-called "median sun". It is this median sun to which the median local time is referred. Hence one should differentiate between the concept of median sun and true sun. These two concepts differ from each other by a small angular and time difference; this difference is called time equation.

Since the shadow of the earth is, of course, produced by the true sun, but UTC time, however, is referred to median sun, the time equation must be taken into account when calculating the shadow zone. Table 1 contains the time equation - in degrees - for 1979. Note that the values change a little from year to year.

Solar Time Angle and Calculation of the Shadow Zone

The term (L_S - Ω) in equation (1) which is not easily handled by the average radio amateur can be conveniently substituted for by the readily available solar time angle and the time equation.

By substituting $\Omega_S + 180° - \Delta_t$ *for* $(L_S - \Omega)$, the equation becomes:

$$H = \frac{R}{\sin D_S \cos i - \cos D_S \sin i \sin(\Omega_S + 180° - \Delta_t)} - R$$

where Δ_t = time equation.

Now the only remaining unknown quantity is the declination of the sun D_S. This quantity is also listed in Table 1 for the year 1979 and holds also for other years without introducing too many errors.

Finally, the height of the earth's shadow in the orbital plane of AMSAT-OSCAR 7 for orbit no. 19 147 on 22 January 1979 can be computed.

Setting:

$$\begin{aligned} \Omega_S &= 61.15° \\ \Delta_t &= -2.84° \\ D_S &= -19.86° \\ i &= 101.50° \end{aligned}$$

we obtain: $(\Omega_S + 180° - \Delta_t)$
$= 61.15° + 180° - (-2.84°)$
$= 243.99°$ and:

$$H = \frac{6371}{\sin(-19.86°) \cos 101.5° - \cos(-19.86°) \sin 101.5° \sin 243.99°} - 6371$$

$$= 739.3 \text{ km}$$

Table I — Sun declination D_S and time equation on an angular scale for every Monday 00.00 hours UTC of the year 1979.

date 1979	sun declination degrees	time equation degrees	date 1979	sun declination degrees	time equation degrees
Jan 1	− 23.06	− 0.79	Jul 2	+ 23.10	− 0.94
Jan 8	− 22.34	− 1.59	Jul 9	+ 22.45	− 1.25
Jan 15	− 21.27	− 2.28	Jul 16	+ 21.50	− 1.47
Jan 22	− 19.86	− 2.84	Jul 23	+ 20.24	− 1.59
Jan 29	− 18.14	− 3.25	Jul 30	+ 18.71	− 1.60
Feb 5	− 16.16	− 3.49	Aug 6	+ 16.92	− 1.49
Feb 12	− 13.96	− 3.57	Aug 13	+ 14.92	− 1.24
Feb 19	− 11.56	− 3.49	Aug 20	+ 12.72	− 0.89
Feb 26	− 9.02	− 3.27	Aug 27	+ 10.35	− 0.44
Mar 5	− 6.36	− 2.94	Sep 3	+ 7.85	+ 0.08
Mar 12	− 3.64	− 2.51	Sep 10	+ 5.25	+ 0.67
Mar 19	− 0.88	− 2.02	Sep 17	+ 2.57	+ 1.29
Mar 26	+ 1.88	− 1.50	Sep 24	− 0.14	+ 1.91
Apr 2	+ 4.61	− 0.97	Oct 1	− 2.87	+ 2.50
Apr 9	+ 7.27	− 0.47	Oct 8	− 5.57	+ 3.04
Apr 16	+ 9.83	− 0.01	Oct 15	− 8.21	+ 3.49
Apr 23	+ 12.26	+ 0.37	Oct 22	− 10.76	+ 3.84
Apr 30	+ 14.52	+ 0.67	Oct 29	− 13.18	+ 4.04
May 7	+ 16.58	+ 0.85	Nov 5	− 15.43	+ 4.10
May 14	+ 18.43	+ 0.93	Nov 12	− 17.47	+ 3.99
May 21	+ 20.01	+ 0.88	Nov 19	− 19.27	+ 3.70
May 28	+ 21.32	+ 0.73	Nov 26	− 20.78	+ 3.24
Jun 4	+ 22.33	+ 0.48	Dec 3	− 21.98	+ 2.64
Jun 11	+ 23.02	+ 0.16	Dec 10	− 22.83	+ 1.91
Jun 18	+ 23.38	− 0.20	Dec 17	− 23.32	+ 1.09
Jun 25	+ 23.41	− 0.58	Dec 24	− 23.43	+ 0.22
			Dec 31	− 23.15	− 0.64

Data courtesy of Deutsches Hydrographisches Institut Hamburg.

Hence, the upper contour of the shadow area is markedly beneath the medium flight height of AMSAT-OSCAR 7. The satellite traveled in sun-light during the entire orbit.

Some readers may be interested to learn that in the sample computation for orbit no. 19 147 the eliptical longitude of the sun L_S was 303.59° and the right ascension of the satellite was 59.60°.

AMSAT-OSCAR 7 at Crossing the Equator

AMSAT-OSCAR 7 was launched on 15 November 1974 and countless amateurs all over the world have used it for establishing radio contacts at all times of the day and night, yet a certain phenomenon has passed virtually unnoticed: Only a few seem to have noticed that the satellite in spite of its many orbits around the earth has never actually "seen" the ground at the equator when crossing it in the ascending direction (south-north). This is not so astonishing, because the equator was always in the earth's shadow when the satellite was traveling in the S/N direction.

The reason for this strange fact is the sun-synchronous type of orbit that AMSAT-OSCAR 7 is in. When crossing the equator in the S/N direction (ascending node) the satellite has always the same angular distance (= solar time angle = local time difference) to the sun and hence to the shadow mid-line (= midnight meridian = midnight local time). Sun-synchronous satellites always cross the equator at the same local time, since the local time is directly related to the sun, and the sun-synchronous satellite proper is by means of the fixed solar time angle also in fixed relation to the sun. This is the basic characteristic of all sun-synchronous satellites.

Now, at what local time (always the same) does the satellite cross the equator in the S/N direction? The solar time angle was calculated according to the method described above and as was to be expected this angle is constant and amounts to 61.1 degrees.

A solar angle of 61.1 degrees means that the equator crossing took place at a point 61.1 degrees from the midnight meridian (midnight local time). 61.1 angular degrees are equivalent to 244.4 time minutes, *i.e.* 4 hours and 4.4 minutes, and it was exactly this time difference in relation to midnight local time at which all S/N crossings took place.

$24^{h}00$ local time - $4^{h}4.4$ min = $19^{h}55.6^{min}$local time

All S/N equator crossings of the satellite on that date as well as on the preceeding and following days were at $19.55.6^{h}$ local time, but always, of course, at different locations (point Y) on the equator.

At 19.55.6 local time all locations on the equator are in the dark (earth shadow), since the sun sets at the equator always around 18.00^{h} local time throughout the year. The accurate times, dependent on the time equation, lie between 17.47^{h} and 18.18^{h} mean local time. Dusk there lasts about 22 minutes. At $19.55.6^{h}$ local time the surface of the earth is already completely in darkness when AMSAT-OSCAR 7, which is still in sun-light, crosses the equator from the South.

The above mentioned statements are valid for the South-to-North equator crossings, but not for the reverse direction North-to-South which always take place under sunlight conditions.

References

1. A. Bohrmann, *Bahnen kunstlicher Satelliten* (Orbits of artificial satellites), *Hochschultaschenbucher* 40/40a.
2. *Meyers Handbuch uber das Weltall* (Meyer's Handbook on Space), *Bibliographisches/Institut Mannheim.*
3. J. Raddatz, *Bahnversatz von Erdsatelliten* (Orbit offset of earth satellites), *CQ - DL* 3/79.

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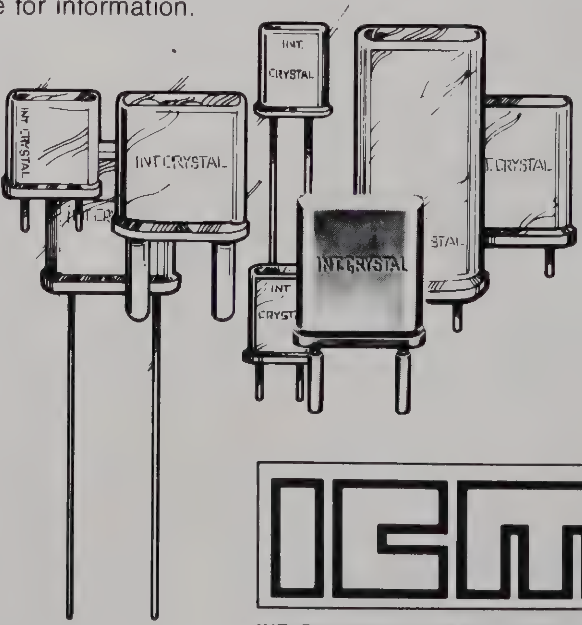

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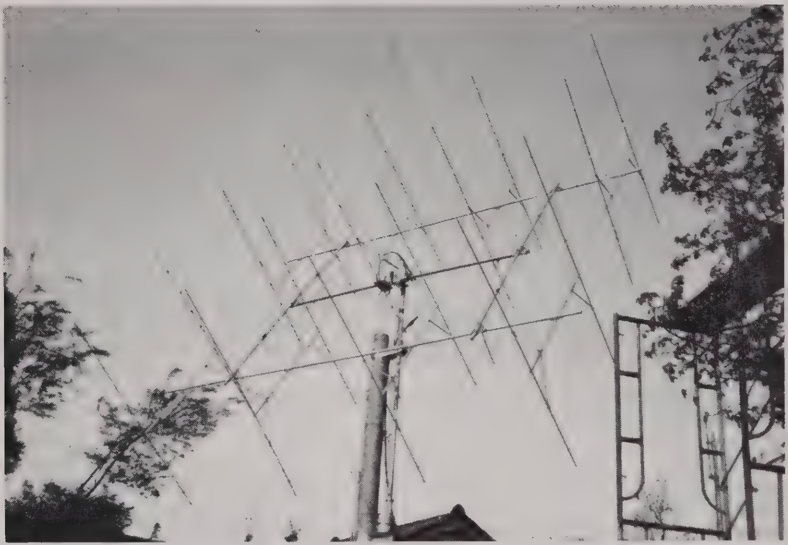
(432 MHz and Above)



By Al Katz, K2UYH*

Conditions were relatively good in February. Good weather in most parts of the world helped activity. Solar activity level was also way up causing the polarization angle on 432 to change very rapidly. Echos were excellent early (on the 14th), but disappeared completely later. Late mail delivery is still a problem, but it is better than before. On 1296 activity level was a little disappointing, but the appearance of WB5LUA with his new 24 foot dish, brightened the day for the lucky ones who worked him.

Skeds Coordinator Found: Charlie, G3WDG (with the help of his XYL Petra, G4KGC) has taken over the job. We have already received his first set of skeds via Telex. (The use of Telex will eliminate the mail delay between the U.K. and U.S.A.)

New Stations: KL7WE is receiving off the moon and should have been on during the March skeds weekend. Tim's new address is 2132 Arlington Drive, Anchorage, Alaska 99503 - Telephone 276-1977. K4PKV in N.C. should be active by the March skeds weekend, but we have no definite word at this writing. Barry, WB4IZR in Georgia was operational in February and should be active again in March. ZS6NG is now operational and should have completed his first contact with ZE5JJ by the time you read this. He will be active during the March skeds weekend provided he has a visable moon. SM5CPD made two QSO's in February and should be workable in March. HB9BPQ is also on again with a very FB signal. TI2NA will be active during the March weekend and wants skeds. XE1RY missed their skeds in January and February, but now have their new F9FT array up and will be active in March. (They are getting 12 dB of sun noise - much more than before.)

VHF Conferences: The West Coast VHF Conference is scheduled for May 1 and 2. The N.E. VHF Conference will be May 16, 17 and 18.

CW: While listening to the February moon signals, it occurred to me that the strongest signals were not always the easiest to copy. Why should this be? A big factor is cw quality. A constant "predictable" rythmn is helpful. Slow cw is definitly not desirable on 432 and 1296 - even if signals are very weak. High speed cw is not always the answer. There seems to be a different optimum cw speed and weighting for different EME conditions. In general cw at 18 or 20 wpm with long spacing between characters (equivalent to 10 wpm) and possible extra emphasis on dahs (but not too much, else the dahs can be broken into dits) is good. The effective EME operator should be able to adapt his cw to the conditions.

OZ9CR: Hans writes that he had converter problems in January and could not make his 1296 skeds. He did transmit and wonders if anyone heard him? We have not received Hans's February report yet, but know of no QSO's with him on 1296. He is back on the skeds list for March.

G3LTF: Peter had a very satisfying February weekend. On 432, on the 13th he worked at 2248 SM2GGF (449/449) and 2315 W6ABN (0/0). On the 14th he worked at 0000 KA0Y (559/559) initial, missed his sked with VK4MC, but QSO'd at 1500 JA9BOH (M/M) initial #54, 1530 JA8QQ (M/M) initial #55, 1550 JA6CZD (339/429) and 1615 DL9KR (449/449) - Jan arranged a 1296 sked with DJ8QL. On 1296 on the 14th at 2100 Peter worked DJ8QL (2nd QSO), then on the 15th he contacted at 0000 WB5LUA (M/M), 0030 K4QIF (449/329), 0100 called by unidentified station and 0135 K2UYH (449/449). He then retuned to 432, but missed an extra sked with W1UHE (confused times) and worked at 2340 HB9BPQ (M/M) and heard W7FU (0), but Gordon did not copy Peter and gave up too early. Back in January Peter worked on 432 ZE5JJ, K4QIF and W0MDL (initial). On 1296 he made no QSO's.

ZE5JJ: Peter had bad weather and was only able to be on for one hour during the February weekend. He made one contact with LX1DB (0/0) for QSO #369. He also heard JA6CZD and DL7YCA. He expects to be on 432 in March (1296 is still not ready), but will be away on vacation in Australia during the April and May skeds weekend. (He will make an effort to be on a few hours during the first day of the EME contest which is the day before he leaves.)

DL7YCA: Manfred reports great success with his new open wire feed array. Besides changing the feed system, he also added two additional elements to each of his 16 DL6WU Yagis. This all resulted in a 2 dB increase in sun noise. He figures 20 deg. from cold sky, 20 deg. from integrated side lobe contributions (ground noise), 30 deg. from his MGF-1412 preamp and 10 deg. from the feedline for a system noise temperature of 80 deg. - not bad at 432! Manfred missed his skeds, but he more than made up on random. On February 13 he worked at 2200 GW3XYW (339/449), 2240 LX1DB (529/539), 2250 W6ABN (339/0), 2312 K4QIF (439/439) and 2350 W7GBI (449/439). Stations heard were G3LTF, G3YGF, G3WDG, DL9KR, ON4DY and W1UHE. On February 14 Manfred contacted at 1320 JA9BOH (339/439), 1342 VK5MC (0/449) and 2150 DL9KR (0/0). Heard were G3YGF, VE4MA and GW3XYW. On Sunday (15th) he QSO'd at 0033 W5FF and K5FF (449/449), SM5CPD (0/0) for initial #77, W0MDL (339/0) and K3NSS (549/0). Heard were W7GBI and SM3AKW. Not a bad start for Manfred's new system.

DL9KR: Jan's February operation was limited by his work schedule. On December 28 he worked SM0EER (0/0) and SM4DHN (0/0). On February 13 he worked LX1DB (559/559), I5MSH (539/529) and W6ABN (449/349). He heard G3LTF (0) and G3YGF (449). On the 14th he QSO'd G3LTF (449/449), DL7YCA (0/0), G3YGF (449/449). He copied GW3XYW (449), VE4MA (0), W6ABN (0), W5FF (0), W7GBI (0), ON4DY (0) and W1UHE (0). (ON4DY was calling W1UHE on .005, but W1UHE was on .000.) Jan also reports that he received a letter and QSL from VK5BKF whom he worked last year during the EME contest. VK5BKF is using 4 loop Yagis and 200 watts. So far Jan is his only QSO.

DJ8QL: On 1296, Franz at 2100 on February 14 contacted G3LTF (M/M) and at 0040 copied and called K2UYH with the edge of his dish touching the ground. Franz has not finished his circular feed, but has been working on his ring amp. He is now getting 420 watts output with 2C39BA's and says that the 2C39's can stand no more than 1500 volts. 7289's can easily take 1600 volts, but Franz has only two of them and would like to obtain more. Can anyone help?

I5MSH: On January 25, the I5MSH station was visited by the local TV reporter. They had an extra sked with W7FU at the time. Fortunately, Gordon showed up with a very clear signal and was QSO'd (0/0) for in-

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*Dept. of Eng. Tech., Trenton State College, Trenton, NJ 08625

itial #94, state 23 and an outstanding demonstration of EME for the news. On February 13 they QSO'd at 2139 DL9KR (529/539), 2215 W7GBI (529/339) and 2325 W6ABN (459/349). They also called at 2355 SM5CPD with no reply. On the 14th they worked at 0006 KA0Y (44/44) on ssb followed by WA7BBM (44/44) on ssb and K2UYH (45/45) on ssb - all on .015. Then they QSO'd at 0130 W7FU (449/559), 0142 W0MDL (0/0) initial #95 and state 24 and 0200 K4QIF (449/439). The next day (14th) they worked at 1512 JA8QQ (439/0) for #96, but heard nil from JA4BLC and only one transmission from JA6AHB who called them on random. Piero reports that LU3AAT is now resettled in Italy.

G3WDG: Bad news, the Oxford group will be QRT on 432 and 1296 until they can find a new location for their 20 foot dish. Can anyone help? The University has installed a satellite receiving system and banned their operation. On February 14 at 2250 G3YGF worked LX1DB (329/439). On the 15th G4KGC running 100 watts worked K5FF (0/M) for the second YL-YL EME QSO and at 2200 G3YGF worked W1JR (0/M).

GW3XYW: On February 13 Stu QSO'd DL7YCA (449/339) at 2200 - Manfred had the best sigs Stu has heard from him in a total of five contacts. At 2300 he looked for K2UYH on ssb in an extra sked, but heard nil (He did hear us later on cw). At 2245 he copied SM2GGF (0). Stu notes a lot of QRM on .010 and thinks that it would help if stations spread out more (random operation is from .005 to .015 with .015 especially for ssb). On Saturday he worked at 2300 VE4MA (M/M), but heard nil from OE6AP at 2230.

DL6WU: Gunter tried to raise K3NSS and I5MSH's attention on random with no luck, but did work on February 14 at 1500 JA6CZD for his fourth continent. Gunter notes that he has had a number of requests for additional information about his 1296 Yagi design. He has prepared information on a new 49 element Yagi (4 M) with more than 18 dB gain which he will supply upon request Just write to Gunter Hock, Gersprenzweg 24, 6100 Darmstadt-Eberstadt, West Germany.

SM3AKW: Karl writes that operating time has been very limited and that he has made only one QSO since September (on December 20 with W7GBI). He is working on a new preamp with an MGF-1402 and is also considering 1296. He reports that OH3TH is making progress repairing his array and that Peter should be back on soon.

JA6CZD: All systems worked fine in February, but high winds prevented Shichiro from making his first hour of skeds. On February 11 he worked K4QIF (439/449), W0MDL (0/0), W1UHE (0/0), JA9BOH (449/549) and W7GBI (439/449). On February 14 he QSO'd VE4MA (439/449), W0MDL (439/0), W6ABN (449/439), W7GBI (439/339), W0RAP (439/439), SM2GGF (439/0), DL6WU (M/M) and G3LTF (429/339). On the 15th he worked W0MDL (0/0). Back in January Shichiro contacted W7FU (0/0), W6ABN (429/339), I5MSH (439/449), SM2GGF (429/339), ZE5JJ (429/0), ZL3AAD (0/0) and JA9BOH (449/449).

JA6AHB: Toshio reports very good conditions. On February 14 he QSO'd at 0505 KA0Y (0/0), 0530 WB5LUA (0/0), 0600 W0MDL (0/0), 0704 VE4MA (0/0), 0825 W7FU (0/0), 0900 JA9BOH (M/M) and 1416 SM2GGF (0/0). On the 15th at 1000 he worked VK5MC (0/0). Stations heard during the February weekend include K3NSS, W7GBI, W0RAP, DL7YCA, ZE5JJ, LX1DB, G3LTF (all 0) and JA8QQ (M). In January Toshio made only two QSO's with JA8QQ and JA9BOH, but heard YV5ZZ, W7GBI, JA6CZD, W7FU, W6ABN and VK5MC.

JA8QQ: Ishio made no QSO's during the special JA skeds on February 11. He did copy W0MDL (0), but heard nil from VE1OD and WB0YSG. On February 14 he worked at 0820 W7FU (0/0), 1500 LX1DB (0/0), 1512 I5MSH (0/439) and 1530 G3LTF (0/M). Other stations heard were K3NSS (549), JA6CZD (449), JA6AHB (0) and KA0Y (0). On February 15 he worked at 0600 W0MDL (0/0), but copied nil from ZL3AAD and VK5MC in extra skeds. Ishio is using 16 H.B. F9FT Yagis and an 8877 final.

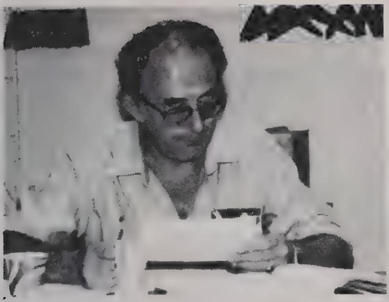
JA9BOH: Kimio reports that the snow is melting, but he still has 180 cm! He worked on January 25 at 1530 VE7BBG (0/0) -chance QSO; February 8 at 0345 JA6CZD (0/0) - polarization tests; February 11 special JA skeds, Kimio worked at 0318 K4QIF (339/449), 0425 JA6CZD (549/449) and 0530 W7GBI heard 439; February 12 0750-0812 nil heard from WB6NMT in special tests; February 14 at 0500 nil from YV5ZZ, 0550 KA0Y (449/449), 0600 VE4MA (0/0), 0800 W7FU (0/0) initial #44, 0830 called by unidentified station, 0857 JA6AHB (M/M), 1315 DL7YCA (339/449), 1400 nil from OE6AP, 1430 LX1DB (0/0) initial #45, 1500 G3LTF initial #46. Other stations copied were K3NSS, WB5LUA, W6ABN, W0RAP, W0MDL, ZE5JJ, I5MSH and SM2GGF. On the 15th he worked at 0630 W0MDL (M/M) initial #47 and 0720 W7FU (339/449).

VK5MC: Chris reports good signals this month. On February 14 on 432 he QSO'd KA0Y (0/0) and DL7YCA (0/0), but heard nil in skeds with W0RRY and W7FU. On February 15 on 1296 he copied K2UYH (M) but had transmitter problems, heard nil from K4QIF, worked VE7BBG (0/0) and heard nil from W6YFK. Then he QSY'd to 432 and worked JA6AHB (0/M) and JA8QQ (M/M). Chris will not be able to be on March 14 between 0500 and 0900.

Comets

Practice Tracking Phase IIIB Now: Avoid the Rush Later!

If you are interested in having a real time demonstration of your access window for Phase IIIB, why not try tracking SRET-2 (1975-49B). This Soviet launched French built spacecraft is in an orbit that is close enough to that planned for Phase III to give most radio amateurs in the northern hemisphere a good enough approximation of their access to Phase IIIB. SRET 2 is transmitting at 132.500 MHz and 137.530 MHz. It was launched on June 5, 1975 from Plesetsk aboard the same launch vehicle as Molniya 45 (1975-49A) and was the second in a series of French experimental satellites in a joint French-Soviet program of space research; the main objectives of the double octagonal, 21.5-kg, 0.56-meter long, 0.56-meter diameter spacecraft, the second *Satellite de Recherches sur l'Environment et la Technologie* was to perform technological experiments and study radiation and thermal control systems under orbital conditions including the qualification of spacecraft systems for future space programs. The onboard experiments comprised a fully-assembled meteorological satellite-type radiometer cooling system and associated electronics and test engineering systems. An onboard modified digital solar sensor acquired satellite attitude data and a telemetry system transmitted engineering and operational data to ground stations at 0.24 watt initially. Power supplies were maintained by negative-on-positive silicon solar cells mounted on SRET 2's structure cell array panels. The spacecraft was commanded and interrogated by French ground stations and telemetry was transmitted from the spacecraft through two crossed dipole antennae deployed after orbital insertion. After ejection from Molniya 45's upper stage, the residual spacecraft rotation of about 0.83 revolutions per minute was nullified by eight 330-mm long, 1-mm diameter internal magnetic rod dampers which interacted with Earth's magnetic field to produce some stabilization while launch vibrations were counteracted by internally-mounted neoprene blocks which also acted as thermal insulation for the internal electronics. SRET 2 also carried a lightweight battery system providing 12 volts at 1.6 watts at launch reducing to about 1.3 watts after one year in space to provide backup power supplies especially during transits through Earth's shadow. One structure-mounted solar cell was a specially-coated cadmium sulphide and cadmium telluride sample cell having a resistance of 1 ohm which was used to measure solar cell degradation. Nominal lifetime was one year but the spacecraft is still transmitting after 5.5 years in space.



G3IOR

Worldwide Satellite Activity

By Pat Gowen, G3IOR*

Keen Oscarator Szigy, YO2IS, teaching junior op. Caius how to pick 'em out of the QRM, while XYL YO2DM operates the station.

From the amount of interest that the activity week aroused it is disappointing that only 20 people took the trouble to enter. Initially organized as a UK event, it was not deliberately intended for overseas entries and so was not initially publicized abroad. The reaction when it was mentioned on the international net was very encouraging and better publicity would obviously have helped. The next Activity Week, probably about May 1981, will be publicized well in advance.

Some comments were made with the entries. Being the first of its kind, rules are hard to get right, and some of the points mentioned with the entries have led me to alter (and stiffen up) the rules for the next one . . . one station didn't like the telemetry requirement; this is the principle advantage to satellite organizations from the activity week, so while I organize it, it stays.

That activity week was close to the anniversary of the launch of AMSAT-OSCAR 7; the next one may coincide with or come close to the date of Phase IIIA's passing.

PLEASE, fellas, join in—*G3RWL*

AMSAT-UK Activity Week Results

Position	Callsign	Telemetry Points	Total Points
1	OK3AU	255	558
2	G4CUO	205	408
3	9M2CR	375	381
4	G3UYM	190	223
5	G2UK	175	184
6	VE2QO	90	143
7	VE5JQ	90	129
8	JE1SPY	85	94
SWL			
1	B. Lindholm (OH)	125	173
2	JR6RNB	20	20

Check logs received (including logs not accompanied by power declaration, points shown) and gratefully acknowledged: G4ERR (292); JA4CMJ (270); W9TGB (212); VE3EFX (108); W5UCY (101); VE3BNO (72); VE3KXF; G5IJ; G4IEH; G3OZT.

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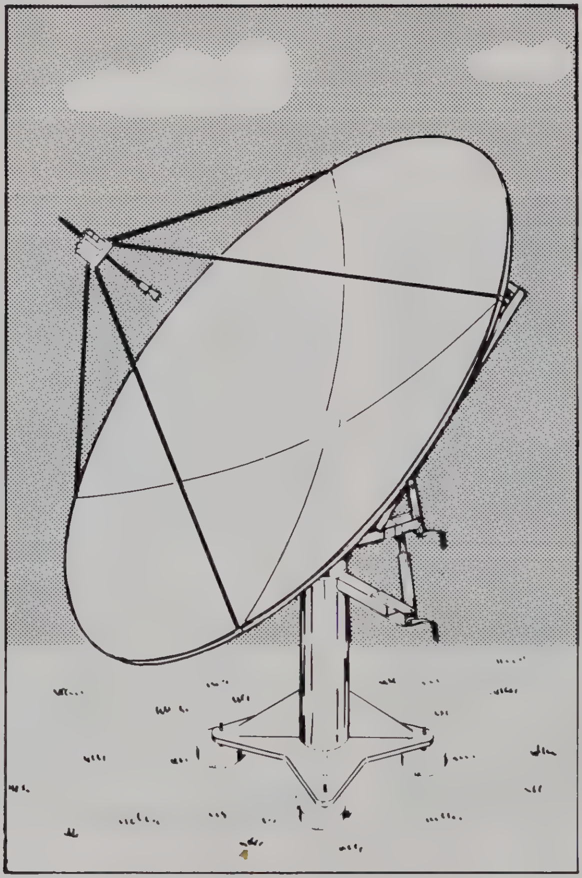

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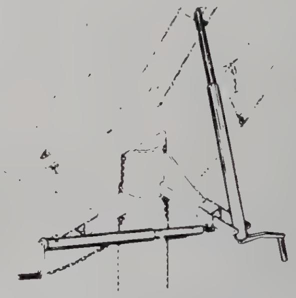

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BASIC Orbits (Continued from page 20)

```
1 PRINT CHR$(12) \ GOTO 360 \ REM — Temporary patch to special user instruction
10 C9$=CHR$(12)+CHR$(7) \ PRINT C9$ \ REM--CLEAR SCREEN STRING
20 PRINT "AMSAT Orbital Prediction Program Package —— May, 1980"
30 PRINT
40 PRINT "  P R O G R A M   R A A N             de  W 3 I W I "
50 PRINT
60 PRINT " Program to convert equator crossing time/longitude to RAAN"
70 PRINT
80 INPUT1 "Epoch: Year = ",Y \ Y=Y/100 \ Y=INT(100*(Y-INT(Y))+.1)
90 IF Y/4=INT(Y/4) THEN F9=1 ELSE F9=0 \ REM--LEAP-YEAR FLAG
100 INPUT1 "   Month (1-12) = ",M \ INPUT1 "   Day = ",D
110 RESTORE 110 \ DATA 0,31,59,90,120,151,181,212,243,273,304,334,365
120 FOR I=1 TO M \ READ D9 \ NEXT \ D8=D+D9 \ IF M>2 THEN D8=D8+F9
130 PRINT "     Day #",D8 \ PRINT
140 INPUT1"Epoch: UTC  Hours = ",H
150 INPUT1"    Min. = ",M
160 INPUT "    Sec. = ",S\ T=H/24+M/1440+S/86400+D8
170 G1=1.0027379093 \ REM--Sidereal to Solar time ratio
180 READ Y1,G2 \ IF Y1=Y THEN 200 ELSE IF Y1>0 THEN 180
190 PRINT "Unable to find Year ",Y," in Sidereal Time Table" \ STOP
200 PRINT \ INPUT "Longitude of EQCR (+west,-east) = ",W
210 G=T*G1+G2 \ REM--GREENWICH SIDEREAL TIME AT T
220 R=G-W/360 \ REM--SIDEREAL TIME AT LONGITUDE
230 IF R>0 THEN 240 ELSE R=R+10 \ GOTO 230
240 R=R-INT(R) \ R=R*360 \ REM--Subtract off bias and convert to degrees
250 PRINT \ PRINT "Right Ascension of Ascending Node = ",R," Degrees"
260 PRINT \ INPUT "HIT RETURN TO CONTINUE",C$ \ GOTO 10
270 REM—Greenwich Sidereal Times on Jan 0.0 in days
280 DATA 79 , 0.2751843198
290 DATA 80 , 0.2745212008
300 DATA 81 , 0.2765959911
310 DATA 82 , 0.2759328721
320 DATA 83 , 0.2752697531
330 DATA 84 , 0.2746066342
340 DATA 85 , 0.2766814244
350 DATA 0,0 \ REM--TERMINATES TABLE
360 PRINT "  TO FIND THE R.A.A.N. FOR THE FINAL LAUNCH TIME:"
370 K=52.775 \ PRINT \ PRINT "   Given Kourou West Longitude = ",K," DEGREES"
380 O=156.4 \ PRINT "Then Terrestrial Longitude ot Ascending Node = ",O+K
390 PRINT \ PRINT "********** NOW TYPE 'RUN 10' *************"
400 PRINT "    Enter the Launch Date and Time"
410 PRINT "    and Enter the Longitude = ",O+K
420 PRINT CHR$(7) \ STOP
READY
RUN
```

```
  TO FIND THE R.A.A.N. FOR THE FINAL LAUNCH TIME:

   Given Kourou West Longitude =  52.775 DEGREES
Then Terrestrial Longitude of Ascending Node =  209.175

********** NOW TYPE 'RUN 10' *************
    Enter the Launch Date and Time
    and Enter the Longitude =  209.175

READY
RUN 10



AMSAT Orbital Prediction Program Package —— May, 1980

   P R O G R A M   R A A N             de  W 3 I W I

 Program to convert equator crossing time/longitude to RAAN

Epocn: Year = 80   Month (1-12) = 5   Day = 23     Day # 144

Epocn: UTC  Hours = 13    Min. = 00    Sec. = 00

Longitude of EQCR (+west,-east) = 209.175

Right Ascension ot Ascending Node =  227.119742712 Degrees

HIT RETURN TO CONTINUE
STOP IN LINE 260
READY
```

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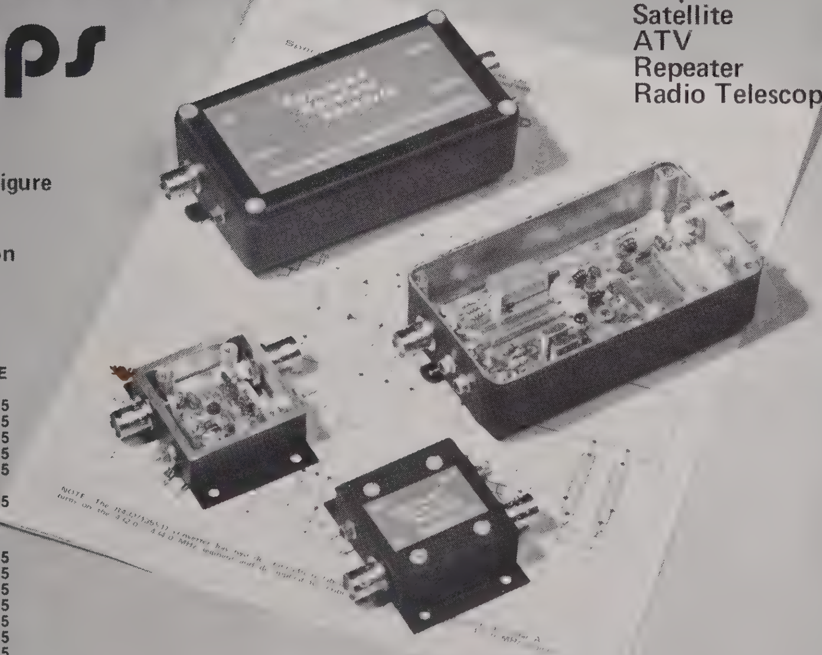

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P50VD	50-54	< 1.3	$29.95
P144VD	144-148	< 1.5	$29.95
P144VDA	144-148	< 1.0	$37.95
P220VD	220-225	< 1.8	$29.95
P220VDA	220-225	< 1.2	$37.95
P432VD	420-450	< 1.8	$32.95
P432VDA	420-450	< 1.1	$49.95

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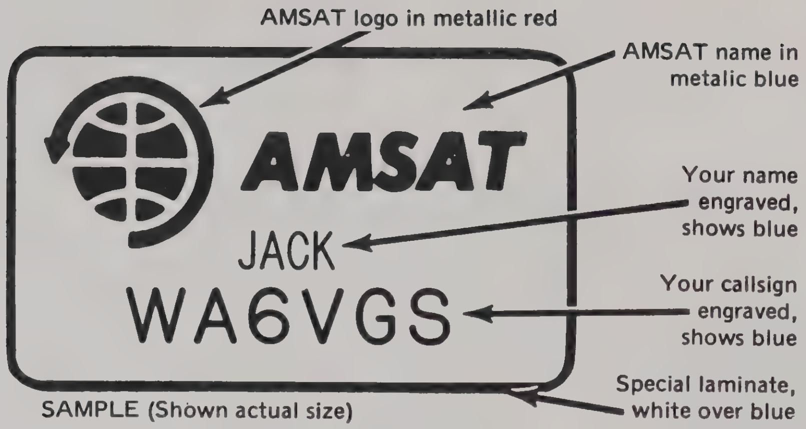
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*City*________________________ *State*________________________ *Zip*____________

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Around the World

By Kaz J. Deskur, K2ZRO*

Articles about the Radio Amateur Satellite Program are being published around the world. Some of this material, which appeared in languages other than English, was never translated and thus did not reach the maximum number of interested readers. *ORBIT* provides abstracts of such articles as they appear, and provide an indication of the level of publishing activity worldwide in the field of Amateur Space activities.

Crystal-Controlled Two-Meter FM Rig as Mode-A Uplink Transmitter

A simple method of rubberizing a crystal in a two-meter fm tranceiver employing 12-MHz crystal oscillators was described in the December 1980 issue of *World Radio* and is shown in Fig. 1. Using this scheme, the entire uplink bandpass can be covered with only one crystal.

The rig used by the author, LA4LN/W3, was a Kenwood TR-2200, but there is no reason to doubt that the above VXO would work in other models as well. LA4LN/W3 was keying his rig with the PTT switch. Actually, PTT keying is not exactly a preferred procedure, and in some rigs causes annoying frequency shift at the leading edge of the dit or dah. I would like to hear from those who successsfully modified their fm rigs for driftless cw operation using a regular key. Please state the make and model number.

Sophisticated Satellite Tracking Program for the TRS-80

The authors, WD8DRK and K8UR, call it *The Ultimate OSCAR Finder* and describe it in the January 1981 issue of *73 Magazine*. It is a program written for the Level II TRS-80 system having at least 16K of RAM. Among more or less conventional tracking data such as EQX of consecutive orbits, Az-El and slant range distance, it also displays the Mutual Visibility Window to any selected geographical locations; indicates AOS and LOS in respect to the tracking station; suppresses orbits out of range; and prints the location of the subsatellite points at one minute intervals. The article shows the data flow diagrams and the actual program written in Microsoft's Level II BASIC. A cassette for TRS-80 and PET is available from GNOME Computerwork, 9918 Lauder, Detroit, MI 48228 for the price of $10 postpaid which also includes a user's guide. The program is applicable to any circularly orbiting satellite as long as its orbital parameters are known.

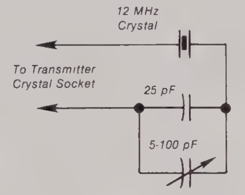


Fig. 1 — Simple VXO circuit with a crystal designed for 145.900 MHz to give continuously variable frequency (± 25 kHz).

ORBITAL PREDICTIONS

By Project OSCAR, Inc.

AO-7 Period (min/orbit) =
$114.94912 - 2.55 \times 10^{-7} \times$ **orbit number**
Ang. Inc. (deg./orbit) = 28.73725°

AO-8 Period (min/orbit) =
$103.24589 - 3.29 \times 10^{-6} \times$ **orbit number**
Ang. Inc. (deg./orbit) =
$25.81296 - 8.1 \times 10^{-7} \times$ **orbit number**

U.T.C. DATE	-- AMSAT-OSCAR 7 --			-- AMSAT-OSCAR 8 --			
	TIME (HMM:SS)	DEG.	ORBIT NUMBER	TIME (HMM:SS)	DEG.	ORBIT NUMBER	SCHED. MODE
WED. 1 APR. (91)	31:40	85.5	29169	117:15	78.4	15658	X
THU. 2 APR. (92)	125:54	99.1	29182	121:58	79.6	15672	A
FRI. 3 APR. (93)	25:12	83.9	29194	126:41	80.8	15686	A+J
SAT. 4 APR. (94)	119:27	97.5	29207	131:25	82.0	15700	J
SUN. 5 APR. (95)	18:45	82.4	29219	136:08	83.2	15714	J
MON. 6 APR. (96)	112:59	96.0	29232	140:51	84.4	15728	A
TUE. 7 APR. (97)	12:17	80.8	29244	2:22	59.8	15741	A+J
WED. 8 APR. (98)	106:32	94.4	29257	7:05	61.0	15755	X
THU. 9 APR. (99)	5:50	79.2	29269	11:48	62.2	15769	A
FRI. 10 APR. (100)	100:04	92.8	29282	16:31	63.5	15783	A+J
SAT. 11 APR. (101)	154:19	106.4	29295	21:14	64.7	15797	J
SUN. 12 APR. (102)	53:37	91.3	29307	25:56	65.9	15811	J
MON. 13 APR. (103)	147:51	104.8	29320	30:39	67.1	15825	A
TUE. 14 APR. (104)	47:09	89.7	29332	35:22	68.3	15839	A+J
WED. 15 APR. (105)	141:24	103.3	29345	40:05	69.5	15853	X
THU. 16 APR. (106)	40:42	88.1	29357	44:47	70.7	15867	A
FRI. 17 APR. (107)	134:56	101.7	29370	49:30	71.9	15881	A+J
SAT. 18 APR. (108)	34:14	86.6	29382	54:12	73.1	15895	J
SUN. 19 APR. (109)	128:29	100.1	29395	58:55	74.3	15909	J
MON. 20 APR. (110)	27:47	85.0	29407	103:38	75.5	15923	A
TUE. 21 APR. (111)	122:01	98.6	29420	108:20	76.7	15937	A+J
WED. 22 APR. (112)	21:19	83.4	29432	113:02	77.9	15951	X
THU. 23 APR. (113)	115:33	97.0	29445	117:45	79.1	15965	A
FRI. 24 APR. (114)	14:51	81.8	29457	122:27	80.3	15979	A+J
SAT. 25 APR. (115)	109:06	95.4	29470	127:09	81.5	15993	J
SUN. 26 APR. (116)	8:24	80.3	29482	131:52	82.7	16007	J
MON. 27 APR. (117)	102:38	93.9	29495	136:34	83.9	16021	A
TUE. 28 APR. (118)	1:56	78.7	29507	141:16	85.1	16035	A+J
WED. 29 APR. (119)	56:11	92.3	29520	2:47	60.5	16048	X
THU. 30 APR. (120)	150:25	105.9	29533	7:29	61.7	16062	A

U.T.C. DATE	-- AMSAT-OSCAR 7 --			-- AMSAT-OSCAR 8 --			
	TIME (HMM:SS)	DEG.	ORBIT NUMBER	TIME (HMM:SS)	DEG.	ORBIT NUMBER	SCHED. MODE
FRI. 1 MAY (121)	49:43	90.7	29545	12:11	62.9	16076	A+J
SAT. 2 MAY (122)	143:57	104.3	29558	16:53	64.1	16090	J
SUN. 3 MAY (123)	43:15	89.2	29570	21:35	65.3	16104	J
MON. 4 MAY (124)	137:30	102.7	29583	26:17	66.5	16118	A
TUE. 5 MAY (125)	36:48	87.6	29595	30:59	67.7	16132	A+J
WED. 6 MAY (126)	131:02	101.2	29608	35:41	68.9	16146	X
THU. 7 MAY (127)	30:20	86.0	29620	40:23	70.1	16160	A
FRI. 8 MAY (128)	124:34	99.6	29633	45:04	71.3	16174	A+J
SAT. 9 MAY (129)	23:52	84.4	29645	49:46	72.5	16188	J
SUN. 10 MAY (130)	118:07	98.0	29658	54:28	73.7	16202	J
MON. 11 MAY (131)	17:25	82.9	29670	59:10	74.9	16216	A
TUE. 12 MAY (132)	111:39	96.5	29683	103:51	76.1	16230	A+J
WED. 13 MAY (133)	10:57	81.3	29695	108:33	77.2	16244	X
THU. 14 MAY (134)	105:11	94.9	29708	113:14	78.4	16258	A
FRI. 15 MAY (135)	4:29	79.7	29720	117:56	79.6	16272	A+J
SAT. 16 MAY (136)	58:44	93.3	29733	122:37	80.8	16286	J
SUN. 17 MAY (137)	152:58	106.9	29746	127:19	82.0	16300	J
MON. 18 MAY (138)	52:16	91.8	29758	132:00	83.2	16314	A
TUE. 19 MAY (139)	146:30	105.3	29771	136:42	84.4	16328	A+J
WED. 20 MAY (140)	45:48	90.2	29783	141:23	85.6	16342	X
THU. 21 MAY (141)	140:03	103.8	29796	2:53	61.0	16355	A
FRI. 22 MAY (142)	39:21	88.6	29808	7:34	62.2	16369	A+J
SAT. 23 MAY (143)	133:35	102.2	29821	12:15	63.4	16383	J
SUN. 24 MAY (144)	32:53	87.1	29833	16:56	64.6	16397	J
MON. 25 MAY (145)	127:07	100.6	29846	21:38	65.8	16411	A
TUE. 26 MAY (146)	26:25	85.5	29858	26:19	67.0	16425	A+J
WED. 27 MAY (147)	120:40	99.1	29871	31:00	68.2	16439	X
THU. 28 MAY (148)	19:57	83.9	29883	35:41	69.4	16453	A
FRI. 29 MAY (149)	114:12	97.5	29896	40:22	70.6	16467	A+J
SAT. 30 MAY (150)	13:30	82.3	29908	45:03	71.8	16481	J
SUN. 31 MAY (151)	107:44	95.9	29921	49:44	73.0	16495	J

U.T.C. DATE	-- AMSAT-OSCAR 7 --			-- AMSAT-OSCAR 8 --			
	TIME (HMM:SS)	DEG.	ORBIT NUMBER	TIME (HMM:SS)	DEG.	ORBIT NUMBER	SCHED. MODE
MON. 1 JUNE (152)	7:02	80.8	29933	54:24	74.2	16509	A
TUE. 2 JUNE (153)	101:16	94.4	29946	59:05	75.4	16523	A+J
WED. 3 JUNE (154)	0:34	79.2	29958	103:46	76.6	16537	X
THU. 4 JUNE (155)	54:48	92.8	29971	108:27	77.8	16551	A
FRI. 5 JUNE (156)	149:03	106.4	29984	113:08	78.9	16565	A+J
SAT. 6 JUNE (157)	48:21	91.2	29996	117:48	80.1	16579	J
SUN. 7 JUNE (158)	142:35	104.8	30009	122:29	81.3	16593	J
MON. 8 JUNE (159)	41:53	89.7	30021	127:10	82.5	16607	A
TUE. 9 JUNE (160)	136:07	103.2	30034	131:50	83.7	16621	A+J
WED. 10 JUNE (161)	35:25	88.1	30046	136:31	84.9	16635	X
THU. 11 JUNE (162)	129:39	101.7	30059	141:11	86.1	16649	A
FRI. 12 JUNE (163)	28:57	86.5	30071	2:40	61.5	16662	A+J
SAT. 13 JUNE (164)	123:12	100.1	30084	7:21	62.7	16676	J
SUN. 14 JUNE (165)	22:29	84.9	30096	12:01	63.9	16690	J
MON. 15 JUNE (166)	116:44	98.5	30109	16:41	65.1	16704	A
TUE. 16 JUNE (167)	16:01	83.4	30121	21:21	66.3	16718	A+J
WED. 17 JUNE (168)	110:16	97.0	30134	26:02	67.5	16732	X
THU. 18 JUNE (169)	9:34	81.8	30146	30:42	68.6	16746	A
FRI. 19 JUNE (170)	103:48	95.4	30159	35:22	69.8	16760	A+J
SAT. 20 JUNE (171)	3:06	80.2	30171	40:02	71.0	16774	J
SUN. 21 JUNE (172)	57:20	93.8	30184	44:42	72.2	16788	J
MON. 22 JUNE (173)	151:34	107.4	30197	49:23	73.4	16802	A
TUE. 23 JUNE (174)	50:52	92.3	30209	54:02	74.6	16816	A+J
WED. 24 JUNE (175)	145:06	105.8	30222	58:43	75.8	16830	X
THU. 25 JUNE (176)	44:24	90.7	30234	103:22	77.0	16844	A
FRI. 26 JUNE (177)	138:39	104.3	30247	108:02	78.2	16858	A+J
SAT. 27 JUNE (178)	37:56	89.1	30259	112:42	79.4	16872	J
SUN. 28 JUNE (179)	132:11	102.7	30272	117:22	80.6	16886	J
MON. 29 JUNE (180)	31:29	87.6	30284	122:02	81.7	16900	A
TUE. 30 JUNE (181)	125:43	101.1	30297	126:42	82.9	16914	A+J

**Box 11, Endicott, NY 13760*

Satellite Log

By Geoffrey Falworth*

Satellite Log features launches into orbit since the beginning of 1980. The satellite name is that assigned by the launching agency (the international designation is in parenthesis) and the orbit (period, inclination to Earth's equator, apogee height, perigee height) is for shortly after launch; later maneuvers may modify this orbit. Transmissions are those which are publicly reported or assumed from the type of spacecraft involved.

Cosmos 1219 (1980-88A) launched on 1980 Oct 31; initial orbit: 89.70 min, 72°.85, 291 km, 228 km; transmissions: 19.989 MHz. Recoverable reconnaissance satellite.

Cosmos 1220 (1980-89A) launched on 1980 Nov 4; initial orbit: 93.24 min, 65°.04, 444 km, 425 km; transmissions: none reported. Ocean radar reconnaissance satellite.

Cosmos 1221 (1980-90A) launched on 1980 Nov 12; initial orbit: 90.33 min, 72°.89, 387 km, 194 km; transmissions: 19.989 MHz. Recoverable reconnaissance satellite.

Satellite Business Systems 1 (1980-91A) launched on 1980 Nov 15; initial orbit: 1436.10 min, 0°.19, 35796 km, 35784 km; transmissions: 43-MHz bandwidths centered at 11725 MHz, 11774 MHz, 11823 MHz, 11872 MHz, 11921 MHz, 11970 MHz, 12019 MHz, 12068 MHz, 12117 MHz, 12166 MHz. Commercial data relay satellite located initially over longitude 105°.86 West.

Molniya 79 (1980-92A) launched on 1980 Nov 16; initial orbit: 717.99 min, 62°.82, 39768 km, 602 km; transmissions: 800 to 1000 MHz, 3400 to 4100 MHz. Molniya 1-class communications satellite.

Cosmos 1222 (1980-93A) launched on 1980 Nov 21; initial orbit: 97.38 min, 81°.23, 633 km, 631 km; transmissions: none reported. Military weather satellite.

Soyuz T3 (1980-94A) launched on 1980 Nov 27; initial orbit: 88.76 min, 61°63, 236 km, 195 km; transmissions: 20.008 MHz, 121.750 MHz. Manned spacecraft (crew: Leonid Kizim, commander, Oleg Makarov, flight engineer and Gennady Strekalov, researcher-engineer) docked with Salyut 6 on 1980 Nov 28.

Satellite News: The news bulletin of satellites, spacecraft and space activity is available in four editions: *Space Objects Digest, Military Space Digest, Space Operations Review* and *Space Systems Digest.* The price is 25 cents per issue: subscribe for as many issues as you like. Payments and orders by International Money Order, cash or check. Please add $2 to personal checks for UK bank charges. Orders should be sent to: Geoffrey Falworth, 12 Barn Croft, Penwortham, Preston PR1 0SX, England.

**12 Barn Croft, Penworthan, Preston, PR 10 SX, England*

LETTERS

Dear Editor:

I really enjoy every copy of *ORBIT* Magazine, if I may suggest, an article that I would like to see in future copies would be on construction of up and down converters, to newcomers like me these would be appreciated.—*VE2XY*

Editors Note: We can only print articles that are sent in to us—prospective authors, here's a subject for you.

Dear Editor:

How about an article on various rotors, control boxes, az/el rotors, etc. Since the Alliance U-100 TV rotor is so reasonably priced, it can very readily be used for elevation control with some mounting modification.

I just recently built a 15-element Quagi for 432 MHz and a six-element Quagi for two meters. In order to work the OSCAR's on direct overhead passes, I found it necessary to install a TV rotor (U-100) as an elevation control. Being able to work OSCAR while it is overhead is much more enjoyable than sitting and waiting for the "bird" to arrive within my antenna beamwidth.—*WB9FRV*

Dear Editor:

There is an OSCAR net which meets on Wednesdays at 0200 UTC on 144.400 USB. NCS is myself, Bill, K3JNZ (Manhatten, NY) and it is a bulletin and informal satellite/vhf net for any interested stations in the New York City area. AMSAT member stations are invited and their check-in is appreciated.—*K3JNZ*

Dear Editor:

I am very happy to announce that the launch of Kiku No. 3 was successful. A Japanese satellite, Kiku No. 3 was launched on February 11, 1981 from Tanegashima-island.

This satellite has long elliptical orbit, so I think it is very useful for practicing tracking Phase IIIB.

According to information in a Japanese electronic magazine the beacon frequencies of Kiku No. 3 are 136.112 MHz (1.5 W) and 1705.0 MHz (2.0 W). 136.112 MHz is the main frequency and 1705.0 MHz is the sub frequency. (Note: Kiku means chrysanthemum in Japanese.)—*JA2WO*

Dear Editor:

I thought I would write and let you and the entire Amateur Radio satellite operators on the status of satellite communications in Hawaii. I know there are many stations searching desperately for that one contact to complete their WAS, WAC, etc. through the satellites. The numbers here are small but are slowly beginning to increase. There is now hope for those who wish to work the Islands.

As of 20 February 1980, the state of Hawaii has the capability to work all of the present modes of operation (A, B and J). There are also three very active satellite stations with a few others which are not as active. The three most active stations are KH6IBA, Carl, who is presently active on Modes A and B; AH6AP, Byron, who is active on Modes A and J; and myself, WH6AMX, being active on Modes A, B and J. We may be found almost nightly on any of the available modes when the orbits are such to give us access to the United States and Asia. Also for those who are interested in setting a schedule with me, please write and let me know the time, mode and orbit number and satellite, and I will be happy to arrange a contact.

One final note to "ZL" stations, I have heard a few New Zealand stations on the AMSAT-OSCAR 7 satellite in both Modes A and B. I have attempted to work the stations I have heard on "A" with no luck. I was not able to work Mode B at the time I heard them. Now that I am active on Mode B, I have begun monitoring the orbits which put me within range of New Zealand. So this is just a note for those who might have given up trying. We are here and we are awaiting for those who would like to work the Hawaiian Islands.—*WH6AMX*

Dear Editor:

I became too disabled to work and had to quit my flying job in Puerto Rico. Now I live on a small Social Security check and my wife had to start to work so we can keep our house.

I have not been able to work the AMSAT-OSCAR satellites due to not having equipment or antennas for Modes B and J.

I still have the Collins "62S-1" which became so popular from KP4DPN, but I would like to sell it (It is still in its original carton with manual and a "spare" never used 4X150A.) for $650.

Now, I still operate mostly on "cw" chasing DX on the HF bands, but miss the thrills of working through OSCAR. I made my Satellite Achievement Award from KP4 when I was the first and only signal there!—*AA4CM*

AMSAT News

Late breaking information can often be obtained joining in the various on-the-air AMSAT nets. The following updates previously published lists:
SW Pacific
Saturday 2200 UTC 28.878 (minus if QRM)
South Africa
Sunday 0900 UTC 14.280 MHz relayed on 7.080 MHz and 2-meter fm repeaters.
Los Angeles, California
Daily 0730 PST 145.775 MHz (USB)
Manhatten, New York
Wednesday 0200 UTC 144.400 MHz (USB)

Organizational items of interest to all members of the Radio Amateur Satellite Corporation

West Coast OSCAR Meetings

California amateur satellite enthusiasts have held a series of meetings during the fall of 1980 in Southern and Northern California. One of these meetings was held the morning of October 4th at the home of John Fail, KL7GRF/W6. In attendance were five Project OSCAR board members, four of which flew to Los Angeles from the San Francisco bay area just for the meetings. They were Jim Eagleson, WB6JNN, Lance Ginner, K6GSJ, John Pronko, W6XN, and Paul Shuch, N6TX. Four AMSAT officials, Tom Clark, W3IWI, Jan King, W3GEY, Bill Brown, K9LF, and John Browning, W6SP, were also present as well as Norm Chalfin, K6PGX, Vic Ruebhausen, W6WNK, Julian Macassey, N6ARE, and Cleyon Yowell, AD6P.

The meeting was held specifically to discuss the potential roll of the Project OSCAR organization (and the growing tide of Amateur Radio satellite support present in California) in the future AMSAT satellite developmental plans. Considering the talent and resources available on the West Coast of the United States, it was decided that at the present time the Project OSCAR organization could best serve the amateur satellite service by joining with AMSAT Canada in building a transponder package for the SYNCART geostationary satellite concept. This program has long been supported by AMSAT and had been originally proposed by the AMSAT Canada group under the leadership of John Henry, VE2VQ.

Although what is presently being supported is a satellite which when in geostationary orbit could serve only Region 2, the concept can be extended to another two or three more satellites positioned around the world such that continuous world wide radio communication coverage would be realized. The satellite output would be in the 70 cm band (435 MHz) while the input would be in two alternately selectable bands, 23 cm (1270 MHz) and 2 m (145 MHz). The transponder would be placed aboard a host satellite. Launch opportunities for the 1983-1984 time frame are presently being investigated. More details on this project will be presented in the near future in *ORBIT* Magazine.

Later that same day a meeting, open to the general public, was held at the officers club of the USAF Space Division Headquarters in El Segundo, California. This meeting was organized by John Browning, W6SP, and was attended by approximately 60. The main speakers were AMSAT's Tom Clark and Jan King. They covered topics such as a Phase IIIA wrap up, plans for the future Phase IIIB satellite and AMSAT's long term objectives. Bill Brown explained some of the details of the fund raising campaign that was about to commence. John Pronko, President of Project OSCAR reported on the decisions made at the meeting held earlier that day and made a general plea for the necessary support needed to bring this project to completion. The remainder of the meeting was open to discussions regarding this synchronous satellite concept.

On November 4th, John Henry, VE2VQ, of AMSAT Canada flew to California from Ottawa for a series of planning meetings regarding the SYNCART satellite. The first meeting was held in the San Francisco bay area at the home of Paul Shuch, N6TX. The meeting was attended by Lance Ginner, K6GSJ, Nick Marshall, W6OLO, Bob Stein, W6NBI, Al Gaetano, W6VZT, Dave Leeson, W6QHS, Doug Oard, WB2HUT/6, and John Pronko, W6XN. John Henry presented the overall proposal for the SYNCART concept; discussions followed the presentation. Since those in attendance were mostly rf oriented, only the plans for the rf transponder were considered in detail. In summary it was decided that the Project OSCAR group in the San Francisco bay area would organize and oversee the responsibility of designing and building the 1270-MHz and 145-MHz input stages as well as the 435-MHz output stage including the down and up conversion to and from the i-f stage. AMSAT Canada would provide the multiple 30-MHz i-f stages and the power regulation system.

On the following day John Henry, VE2VQ, and John Pronko, W6XN, flew to the Los Angeles area for a meeting at the home of John Fail, KL7GRF/6. In attendance for this meeting were Julian Macassey, N6ARE, Vic Ruebhausen, W6WNK, Vince Keyuravong, Paul Merget, John Browning, W6SP, Verne De Forest, Cleyon Yowell, AD6P, Skip Reymann, W6PAJ, and Phineas Icenbice, W6BF. John Henry again presented the general SYNCART proposal for consideration. This was followed by detailed discussions on the microprocessor housekeeping control system which would fly along with the transponder. In summary, it was decided that the Project OSCAR group in the Los Angeles area would organize and oversee the responsibility of designing and building the onboard microprocessor system. Both Project OSCAR groups will meet independently early in January 1981 to finalize details and assign final hardware responsibilities to individuals or groups of individuals interested in participating. In the meantime, AMSAT Canada and Project OSCAR will prepare a written budgetary and construction schedule for consideration by the AMSAT Board of Directors. Individuals or organizations wishing to support this project should contact AMSAT Headquarters in Washington, D.C.—*W6XN*

Frequencies for AMSAT Phase IIIB

After consideration of all technical and operational aspects AMSAT has preliminary fixed the following frequencies for the next AMSAT Phase III satellite.

U-Transponder
Uplink:
435.300 - 435.150 MHz
Downlink:
Transponder: 145.820 - 145.970 MHz
Engineering Beacon: 145.990 MHz
General Beacon: 145.8125 MHz

L-Transponder
Uplink:
1269.950 - 1269.150 MHz
Downlink:
Transponder: 436.150 - 436.950 MHz
Engineering Beacon: 436.020 MHz
General Beacon: 436.040 MHz

AMSAT invites comments to this frequency selection and is prepared to change these frequencies if serious problems are anticipated. Comments should reach AMSAT-DL not later than April 15 because of total schedule constraints.

Will Webster, WB2TNC, Resigns from AMSAT

Will Webster, WB2TNC, best known as the voice of WA3NAN from his net control activity resigned from his active role in AMSAT as of 6 January 1981.

Will has made many important contributions to the Radio Amateur Satellite Program. His wise council and abundant humor will be sorely missed. The departure of the familiar voice of AMSAT is a particularly significant loss to our worldwide membership.

Will's place on the board of directors is being filled by John Henry, VE2VQ, until the election to be held at the annual general meeting.

Call for Nominations

Elections to the Board of Directors will be held at the 1981 Annual Meeting. The terms of John Browning W6SP, John Henry VE2VQ, and Jan King W3GEY, expire this year.

Candidates may be nominated by Member Societies or by a letter of nomination signed by at least five members. (A special form is not required.) The deadline for submitting such nominations is 15 June 1981.

Candidates will be expected to supply background and biographical information.

Southern Africa AMSAT

An all day satellite conference presented by S.A. AMSAT held at the Jan Smuts Holiday Inn outside Johannesburg on November 1, 1980 was attended by amateurs from all over South Africa and Zimbabwe.

The conference opened at 8:30 a.m. with a welcoming address by ZS1BI. The Official opening speech was presented by Professor Louis van Biljon of the University of Pretoria. In his interesting speech he paid many compliments to the amateur community and stated that he was most impressed with the ease with which amateurs were able to grasp and keep up with the latest developments. He pointed to the growth of communications satellites and said that within a few years there would be over a million ground stations for reception of television from satellites.

At 9 a.m. the first paper, entitled "Satellite Orbit Determination using Single Station Doppler Observations" by ZS1BI was read. It was shown how it was possible to determine the orbits of unidentified transmissions and hence identify the satellite using simple mathematics. It is theoretically impossible to determine an orbit using single station doppler observations but since this method has worked for at least fifteen satellites it proves that theory is not everything. Although this was a technical paper, it aroused considerable interest as there were numerous requests for reprints of the paper.

At 10 a.m. Hans, ZS6AKV spoke on Russian Satellites and summarized what was known of the amateur satellites launched by the Soviet Union and what was expected in the near future. At 10:30 the meeting broke for tea, and the exhibits by HAMRAD and WILD and MARR were examined.

At 11 a.m. Heinz, ZS2BD gave a most informative talk on "How to Work DX on OSCAR 7 and 8" and gave valuable pointers on how to work DX, propagation conditions and equipment requirements. The discussion period that followed showed that each operator had his own technique for operating. Heinz also stressed that for DX contacts, contacts must be kept to the barest minimum as others may also be waiting.

This talk was followed by "AMSAT-Phase III." Greg, ZS1BI summarized the progress to date and what the future held for the amateur community. He strongly stressed the need of AMSAT for funds if the satellite is to be ready in time and gave examples of the kind of support being received from various parts of the world. The needs of AMSAT for more assistance in the technical and other fields was also stressed.

Lunch and liquid refreshment then followed and the conference reconvened at 1400 hours with a talk by Peter, ZE5JJ on "How to Get Started on Moonbounce—A Practical Approach." This was the highlight of the meeting and was well illustrated with slides. Peter covered all aspects of EME and proved the success of EME by playing back tapes of QSO's had. One was even on ssb and although the signal report given was 44, it was perfectly readable. Most of Peter's equipment is homebrew, including his magnificent 10 meter radio telescope or dish which is an engineering marvel and took him 18 months to build.

Peter concluded by saying that he was now preparing for 23 cm operation and contemplated doing some radio astronomical observations.

Due to pressure of time, a lengthy question period could not be held but it was apparent that interest was very high and Peter spent the rest of the day answering questions whenever anyone could catch him.

Tea was then served and the final paper on UoSAT, sent by Dr. Martin Sweeting, G3YJO was read to the audience. This was the first time a technical paper had appeared on UoSAT.

The conference finally ended at about 16:30 with free liquid refreshment from WILD and MARR and a small cocktail party.

At 17:30 the Annual General Meeting of S.A. AMSAT was held and was reasonably well attended. The results of the nominations for new Office bearers was announced as follows:

President	Greg Roberts ZS1BI
Vice President	Heinz Buggert ZS2BD
Sec./Treasurer	Henry Stephan ZS1AF

Permission to form a Regional Working Group in Port Elizabeth was formerly granted and brings the total to five. The S.A. AMSAT publication *Satellite Communications* has been discontinued and replaced by the official AMSAT publication *ORBIT* Magazine which is becoming recognized as *The Space Age Magazine*. This was felt by all to be a great forward step. Various projects, availability of kits and other satellite operating equipment was discussed and under General, a considerable amount of discussion was had on various matters including the relations of S.A. AMSAT with the amateur community. The meeting closed with the decision to hold the next conference and AGM in Cape Town in mid-October 1981.

All in all it was a most enjoyable day and an ideal chance to meet well known callsign holders and put a face to the voice. It would appear that the satellite conference will become a regular feature in the South African amateur calendar. Due to numerous requests it is hoped that the next conference will feature talks on Weather Satellite Picture Reception and also Television Reception from Satellites. These are both rapidly growing fields of interest. S.A. AMSAT would like to express its thanks to the sponsors who made the conference possible.—*ZS1BI (Radio ZS)*

Will the Real OSCAR 9 Stand Up

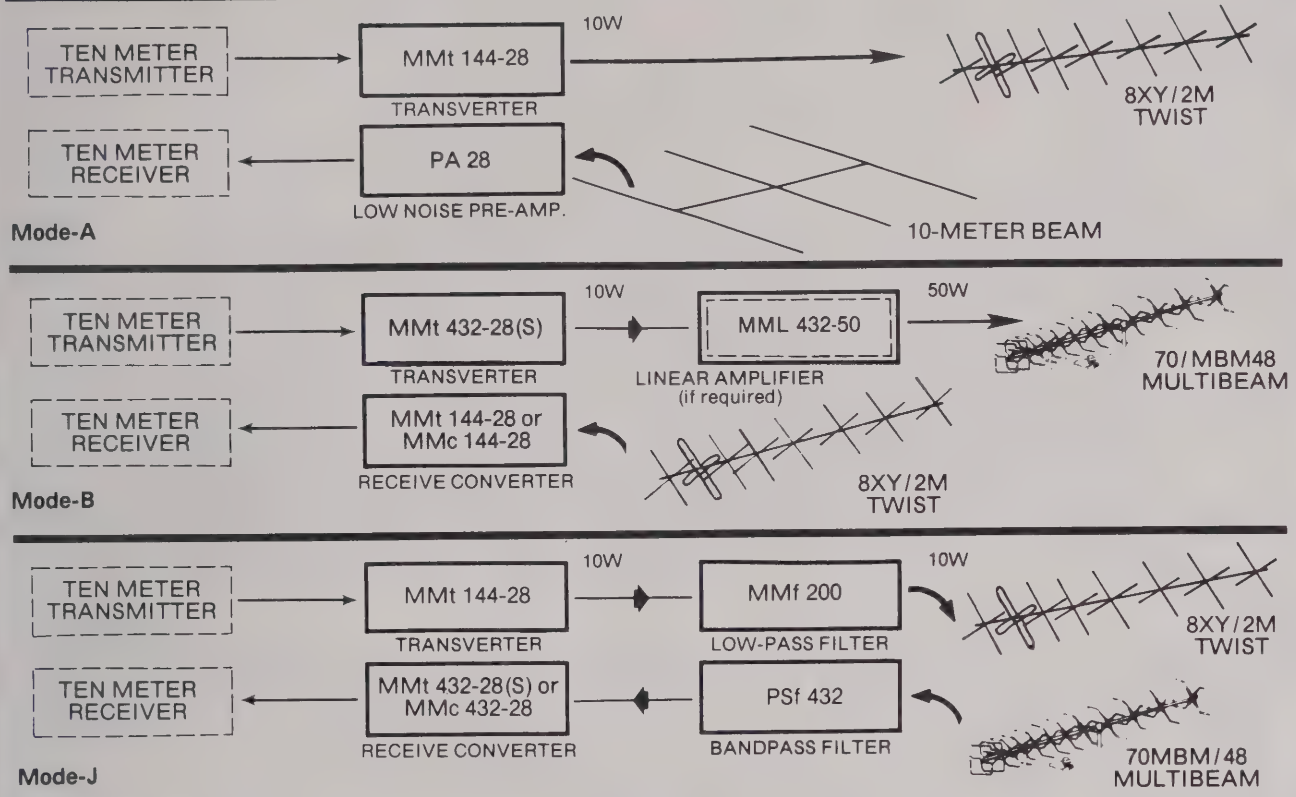
There seems to be a lot of confusion about the naming of spacecraft in the OSCAR series. The names OSCAR 9 and Phase III are used interchangeably without any real understanding of the difference between them.

Spacecraft have traditionally had two names or designations. One name is used to designate the spacecraft before launch, the other is used following a successful launch. The two most popular reasons for this procedure are: (1) that several identical spacecraft are built and only one or two get launched, and (2) that in the early days, launch vehicles were so unreliable that if every malfunction had been counted in the series, the number would get very big very fast.

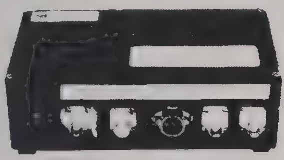
It is for this reason that AMSAT-OSCAR's 5, 6, 7 and 8 were designated AMSAT-OSCAR's A, C, B and D respectively. Note that the C unit was launched before the B unit. The AMSAT Phase IIIA spacecraft would have become AMSAT-(OSCAR) 9 if its launch had been successful. Since the launch was a failure, the next successful launch in the OSCAR series will become known as something-OSCAR 9. The next OSCAR series spacecraft scheduled for launch carries the designation UoSAT until its launch day. If all goes well, UoSAT will become AMSAT-OSCAR 9 and the Phase IIIB spacecraft will in turn become AMSAT-OSCAR 10.—*G3ZCZ*

A recent Project OSCAR meeting in El Segundo, Calif. Seated around the table (left to right) are W6CG, W6ZN, W6HEW, W6ELT, W6WNK, all listening to W6SP discuss a recent AMSAT Board Meeting.

OSCAR SYSTEMS FROM SPECTRUM INTERNATIONAL



CONVERTERS AND TRANSVERTERS FOR



OSCAR 7
OSCAR 8
PHASE III

Specifications:
Output Power: 10W.
Receiver N.F.: 3 dB typ.
Receiver Gain: 30 dB typ.
Prime Power: 12 Vdc

Receive Converters
MMc 144 $59.95
MMc 432-28(s) $81.50
MMc 432-28(TC) $79.95

UHF Filters:
MMf 200-5 $31.95
MMf 200-7 $42.95
PSf 432 $59.95

Receive Preamplifier:
PA-28 $35.95

Mod. kit to adapt original MMt 432-28 FOR Mode-J operation: $26.50

Transverters by Microwave Modules and other manufacturers can convert your existing low-band rig to operate on the VHF and UHF bands. Models also available for 2M to 70 Cm and for ATV operators from Ch2/Ch3 to 70 Cm. Each transverter contains both a Tx up-converter and an Rx down-converter. Write for details of the largest selection available.

Attention owners of the original MMt 432-28 models: Update your transverter to operate OSCAR 8 and Phase III by adding the 434 to 436 MHz range. Mod. kit including full instructions is $26.50 plus $1.50 shipping.

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Rickerson Returns

A print by a famous American space-age artist offers you a chance to help launch the AMSAT satellite.

The response was great. A few months ago JS&A offered a limited edition print by American artist, Mark Rickerson, in a similar style to the print shown above.

THE SUCCESS

There were only 300 prints available. Although we expected to get more orders than we had prints, we did not expect the several thousand responses we eventually received.

THE FAILURE

Another famous program, however, was not successful. A satellite, built by world amateur radio operators in 1980 and placed on a European rocket, crashed into the ocean almost immediately after take-off. The AMSAT satellite and the rocket were lost, along with the hopes of amateurs who had worked for years building their satellite.

The JS&A program was a success. But JS&A's program and the AMSAT failure have something in common – a great opportunity for the public. Let us explain.

AMSAT was a private venture based strictly on donations. No government money was used. In addition to the thousands of man hours contributed by amateurs world-wide, there was a total of $250,000 raised to buy materials.

Why do amateurs even need a satellite? Amateurs or ham radio operators (not to be confused with citizen band operators) are always the first on a scene in a major disaster. During the Italian earthquake, for example, amateurs were first to direct relief efforts.

But occasionally a disturbance in the ionosphere will interrupt this communication and render all radio communications inoperative, as was the case in the Alaskan earthquake. That's only one of the many reasons for AMSAT – positive communications in times of emergencies and not dependent on the ionosphere. JS&A thinks the venture deserves the support of all Americans, and we are providing our full financial and creative support to a program to help raise funds to build and launch a new AMSAT satellite.

THE PROGRAM

JS&A commissioned Mark Rickerson to paint "AMSAT" – a painting to be used exclusively for this space effort. From this painting, JS&A has arranged with Rickerson to produce limited edition prints signed by the artist. JS&A will contribute all prints and the full costs to produce these prints to the program. Only the cost to run the advertisement in a magazine will be covered by the initial proceeds.

Each print has a 26" x 35" image size on a 34" x 42" piece of museum-quality PH balanced 100% rag content paper. The print will be shipped in a well-protected circular cardboard double container. Your contribution of $300 will also entitle you to a handsome certificate suitable for framing to acknowledge your active participation in the new AMSAT launch. A certificate of authenticity will also accompany the print should you wish to sell or donate it to someone in the future.

Each color of this multi-colored painting will be faithfully reproduced in a special collotype process utilizing a continuous tone printing process, several printing plates and the artist's supervision and approval to provide an almost three dimensional reproduction.

Dr. Tom Clark, a NASA scientist and president of the AMSAT organization, says, "We need the cooperation of the American citizen to make this program a success. I urge all Americans to participate. Not only is the reproduction a beautiful piece of art, but the contribution is to a very worthwhile cause. In addition to its use during emergencies, we will be using AMSAT for educational purposes to train many of the potential young scientists in our country."

The edition will be limited to those who subscribe before the deadline date of June 30, 1981. The publication you are reading has helped us in this program by giving us a good position in their magazine and allowing us every available discount to keep the expense of this program low.

To order, send your check or money order for **$300** made payable to AMSAT to Dept. OR, JS&A Group, Inc., One JS&A Plaza, Northbrook, Illinois 60062. If for any reason you are not satisfied with your print, you may return it anytime this year for a prompt and courteous refund.

JS&A had a success with its limited edition print program earlier this year. The AMSAT program suffered a failure. Why not join with us to make their launch a huge success? Order your Rickerson AMSAT print, today.

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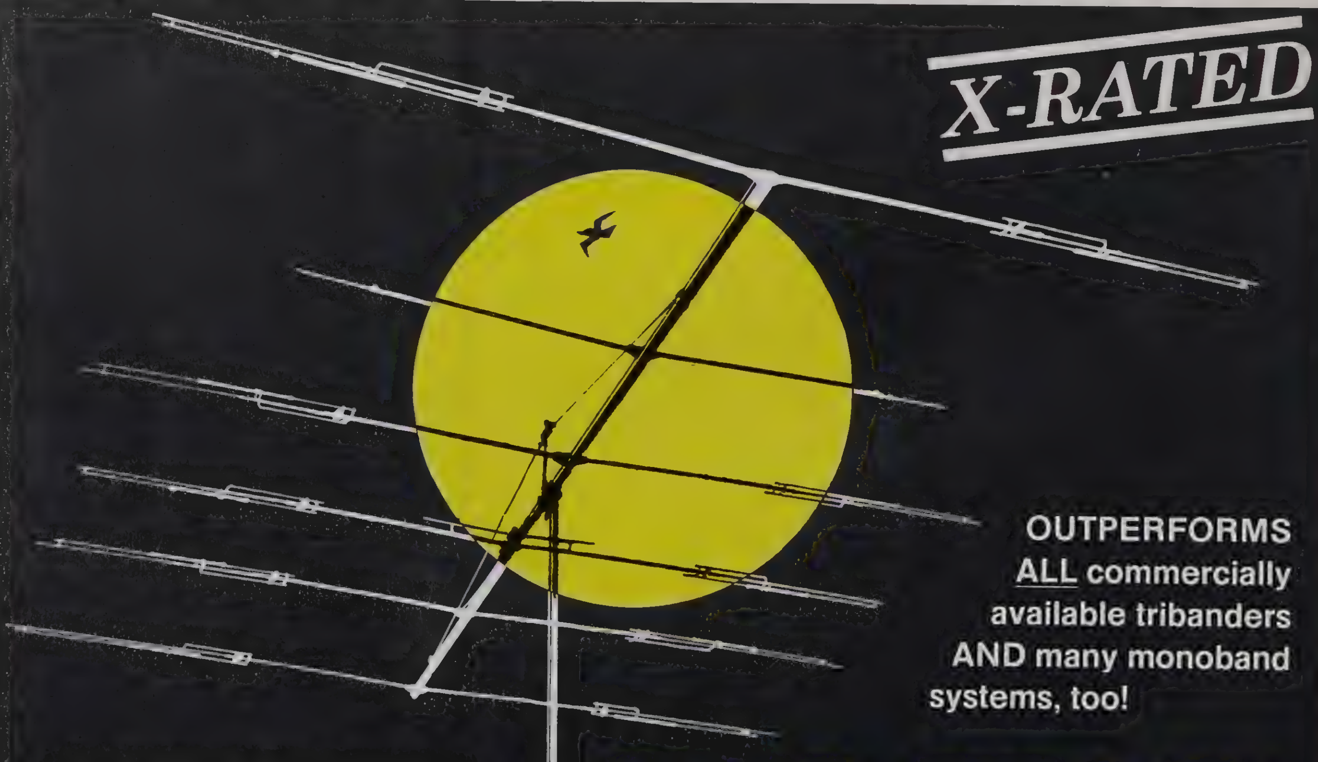

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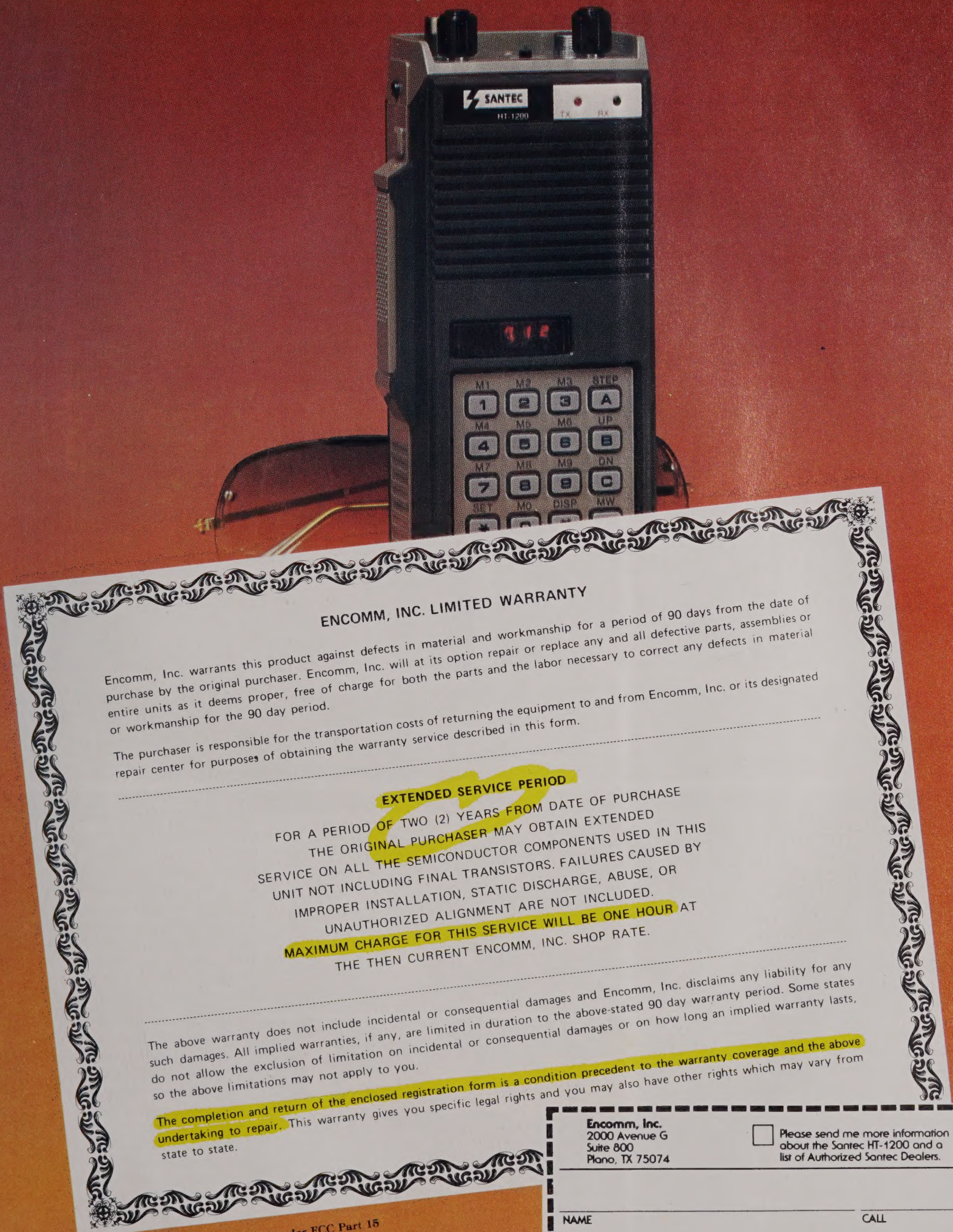

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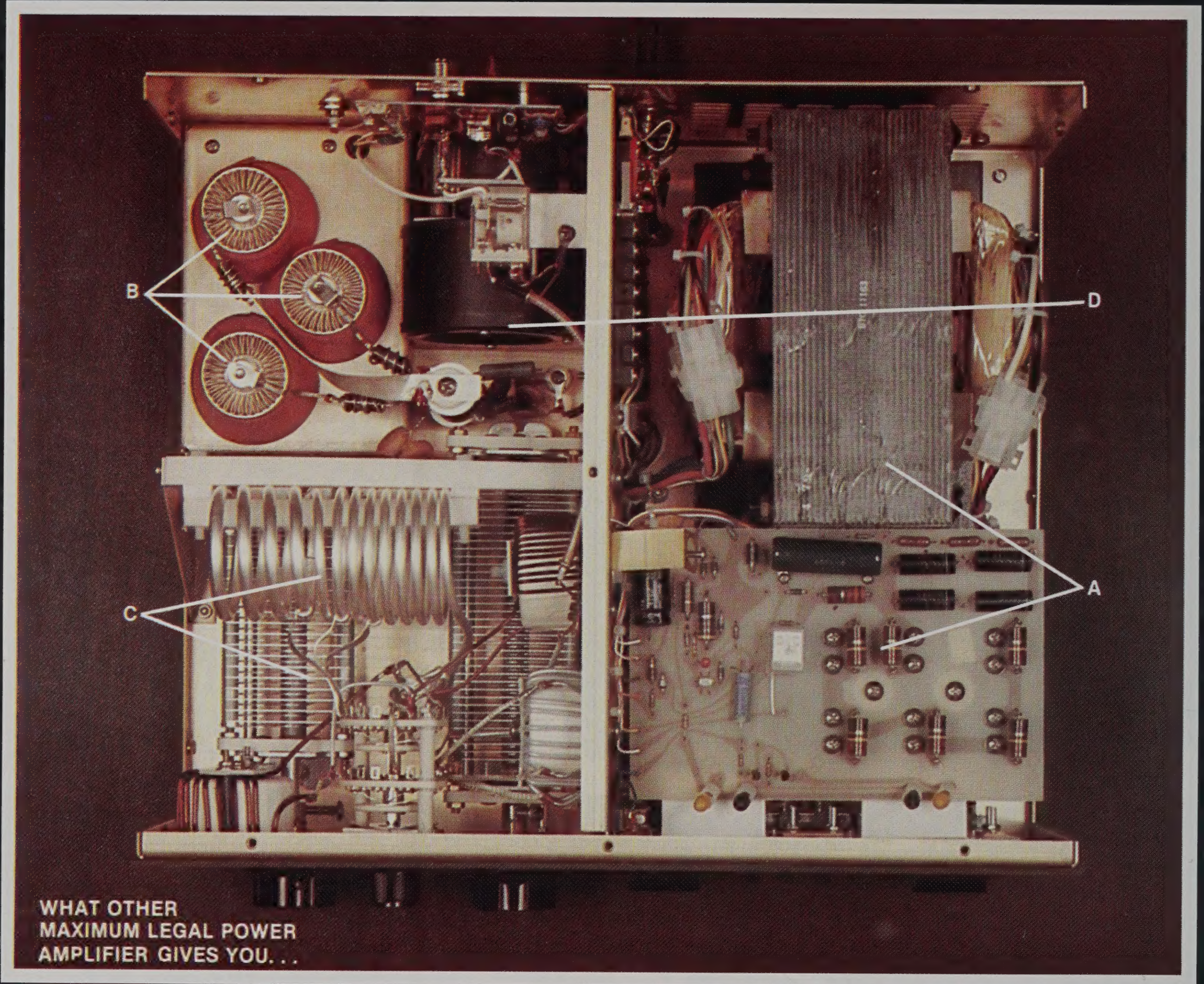

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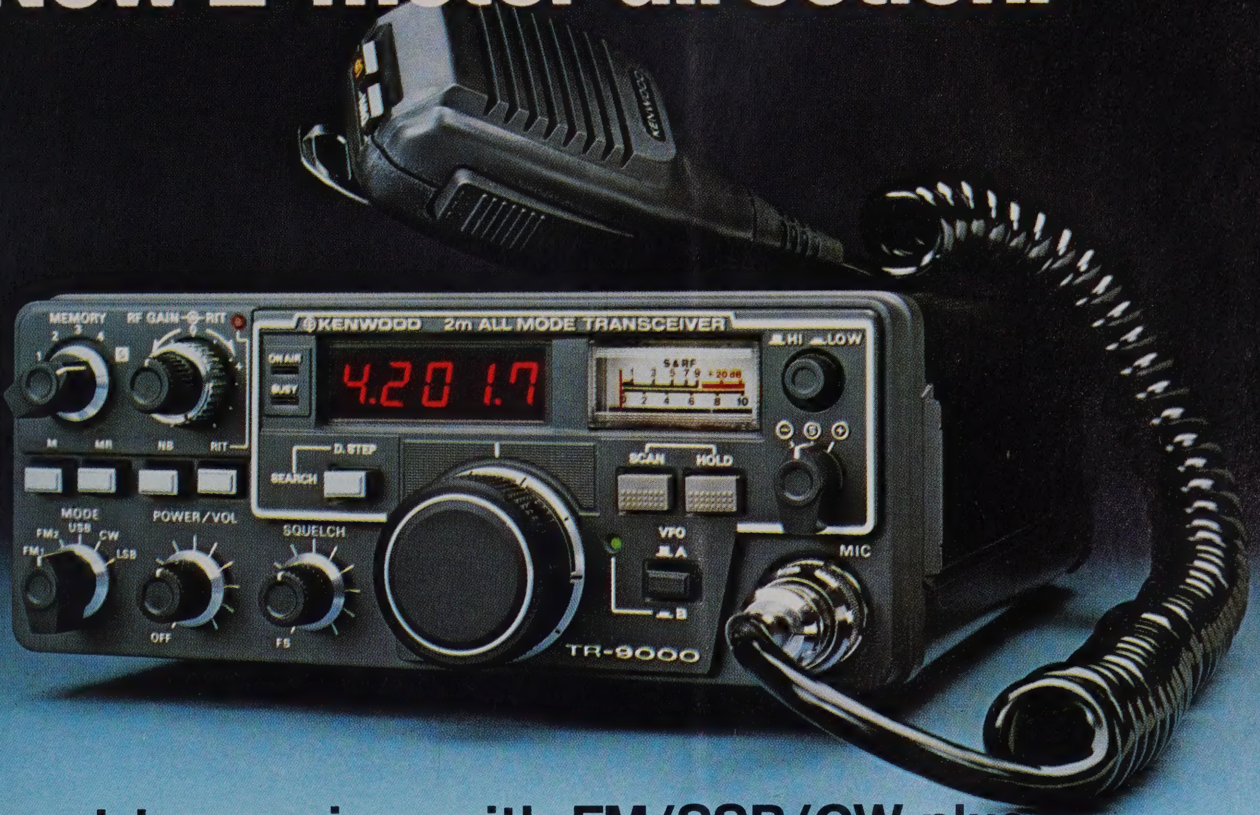

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The exciting TR-9000 2-meter all-mode transceiver combines the convenience of FM with long-distance SSB and CW in a very compact, affordable package, ideal for mobile installation. With its fixed-station accessories it becomes the obvious choice for your ham shack.

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  All the popular 2-meter modes.
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  Covers all 2-meter Amateur frequencies as well as MARS and CAP frequencies (simplex and any repeater split) between 143.9000 and 148.9999 MHz.
- **Digital dual VFOs**
  With selectable tuning steps of 100 Hz, 5 kHz, and 10 kHz, convenient for each mode of operation.
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  Five, four, or three digits, depending on selected tuning step.
- **Scan of entire band**
  Automatic busy stop and free scan.
- **Five memories**
  M1-M4...for simplex or ±600 kHz repeater offset. M5...for nonstandard offset (memorizes transmit and receive frequency independently).
- **SSB/CW search**
  Sweeps between 0 and 9.9 kHz around the selected frequency in 100-Hz steps, while the main knob selects in 10-kHz steps. Easy way to find SSB or CW activity.
- **UP/DOWN microphone**
  "Beep" sounds with each frequency step. (Supplied with TR-9000.)
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  Suppresses pulse-type noise on SSB and CW.
- **Improved receiver front-end characteristics**
  Low-noise, dual-gate MOSFET and two-stage monolithic crystal filter.
- **RIT control**
  Receiver incremental tuning, to tune only the receiver slightly off frequency in the SSB/CW mode. Functions on memory, also.
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  Enables monitoring of keying during CW operation.
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Matching accessories for fixed-station operation:
- PS-20 power supply
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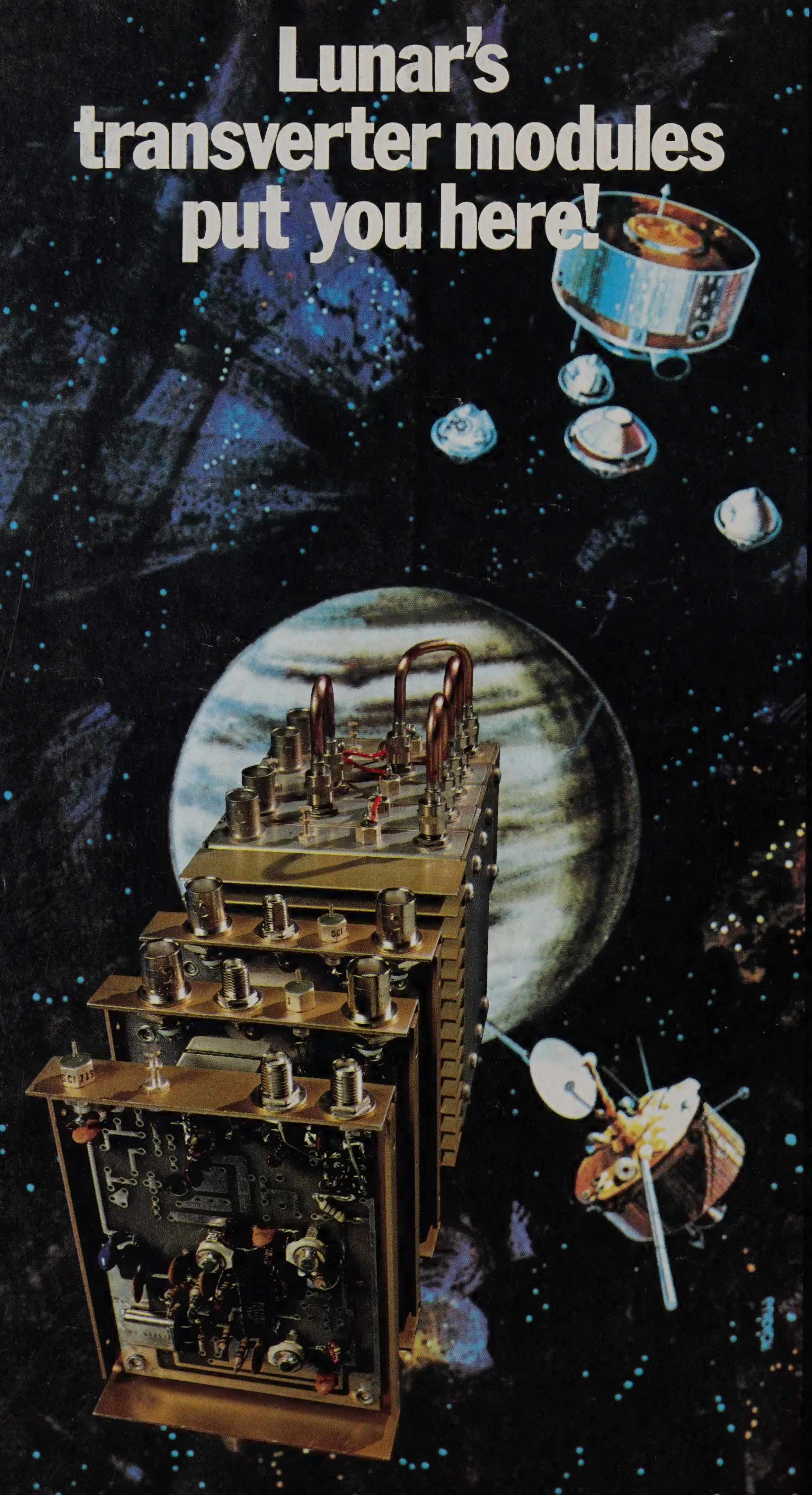

Adding various combinations of Lunar's transverter modules to your present station greatly expands your capabilities to: work an Oscar including Phase III; receive noise from the sun for solar flare investigation or for plotting galactic noise sources; receive weather satellite transmission ; or practically anything else found on HF through UHF.

Our transverter modules are distinctly different from the usual transverter or the home built transverter module. With the single band transverter you must purchase a different unit for each additional band you wish to cover.

Lunar's transverter modules, on the other hand, start with the basic down converter for receive and up converter for transmit. Selecting an appropriate local oscillator module determines the band. Additional modules are added to achieve desired receiving NF and/or output power. Changing the local oscillator module changes the band. Pre amps you already have or might build may be used as desired, similarly, for the transmit side.

It's easier than building your own modules from scratch, and costs much less than buying a complete transverter for each additional band.

Some examples of expected performance using Lunar modules.

EXAMPLE 1

Selected modules:
DC 28
LO 28/144
UC-VHF
PAD 144
PAM 144

This combination gives you:
RF: 144 to 146MHz
IF: 28MHz to 30MHz
Conversion Gain: 25dB
Overall NF: 2 dB nom. 1.6 dB typical
Image Rejection: –30 dB typical
LO Purity: –50 dB max. all spurs & harmonics
Drive 28MHz: 1 to 5 mW
Power Output: 20 watts min.
Operating Voltage: 24VDC @ 2.5 amps. nom.

EXAMPLE 2

Modules added to Ex. 1
LO 28/220/222
PAM 220
PAD 220

This gives you:
RF: 220-222, 222-224MHz
Conversion Gain: 22 dB
Overall NF: 2.5 dB typ., 2.2 nom.
Other specs. remain the same.

If you have a specific band you'd like to cover, write or call us and we'll be happy to discuss it with you. Or send for our literature on transverter modules.

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